

# **Modeling Business Process Workflow of SMEs Using Environment Based Design with a Case Study of Valtech Fabrication Incorporation**

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## **Abstract**

Modeling Business Process Workflow of SMEs Using Environment

Based Design with a Case Study of Valtech Fabrication Incorporation

Mojtaba Niazalizadeh Moghadam

Small and Medium-Sized Enterprises (SMEs) account for over 95% of firms in most countries. In Quebec, SMEs account for 96% of all businesses. SMEs are important for economic growth and they are strong contributors to productivity. Some of the challenges of SMEs are the lack of financing, difficulties in using technology, constrained managerial capabilities, or inefficient productivity.

Among challenges of SMEs, finance and inefficient productivity can be considered as two of the most important issues that slows down their growth. Finance issues can be referred to as the lack of money in investing in new technologies, hiring competent resources, and investing in new equipment. To improve the financial status of a company and increase the profit, we can either increase the revenue or decrease the expenses. The objective of this project is to target the finance issue as well as inefficient productivity of the SMEs and improve both of them by developing a workflow model. Workflow refers to a method for improving business process management, and an effective workflow can help the decision-makers in an enterprise to develop pathways leading to the reduction of costs and wastes. It employs the Environment Based Design (EBD) methodology which not only designs an effective workflow but also analyses the environment of the business to find the root causes of the issues to help the SMEs improve their finance issue by increasing the operation and production efficiency and effectiveness

## Acknowledgments

The author of this paper has worked on the developing a workflow modeling for Valtech Fabrication Incorporation. Due to the agreement that Concordia has signed with Valtech, the author has permit from a company to use real projects as the case study.

This is to state that the case study is associated with real industrial project of the company. Regarding the case study, two things can be stated with confidence because of the author's rich working experience in industry:

- For the purposes of showing EBD approach to develop workflow model, there is no difference between the workflow model used here and that of in use in the company;
- The examples and method chosen are comparable to the real world. Consequently, this thesis does not break any confidential agreement.

I would like to thank Professor Yong Zeng for constructive suggestions and guidance during my graduation period. I thank him for helpful suggestions and his constant encouragement.

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## **Abbreviations**

SME: Small and Medium Sized Enterprises

EBD: Environment Based Design

Valtech: Valtech Fabrication Incorporation

ERP: Enterprise Resource Planning

ROM: Recursive Objective Model

FCC: Fluid catalytic cracking

OECD: Organisation for Economic Co-operation and Development

PM: Project Manager

QCM: Quality Control Manager



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# Chapter 1

## Introduction

### Background

According to OECD (Canada is one of the members), small and medium sized enterprises (SMEs) account for over 90% of firms and employ 63% of workforce in the world [1]. SMEs play an important role in economic growth of OECD countries. Figure 1 shows the share of SMEs in business firms.

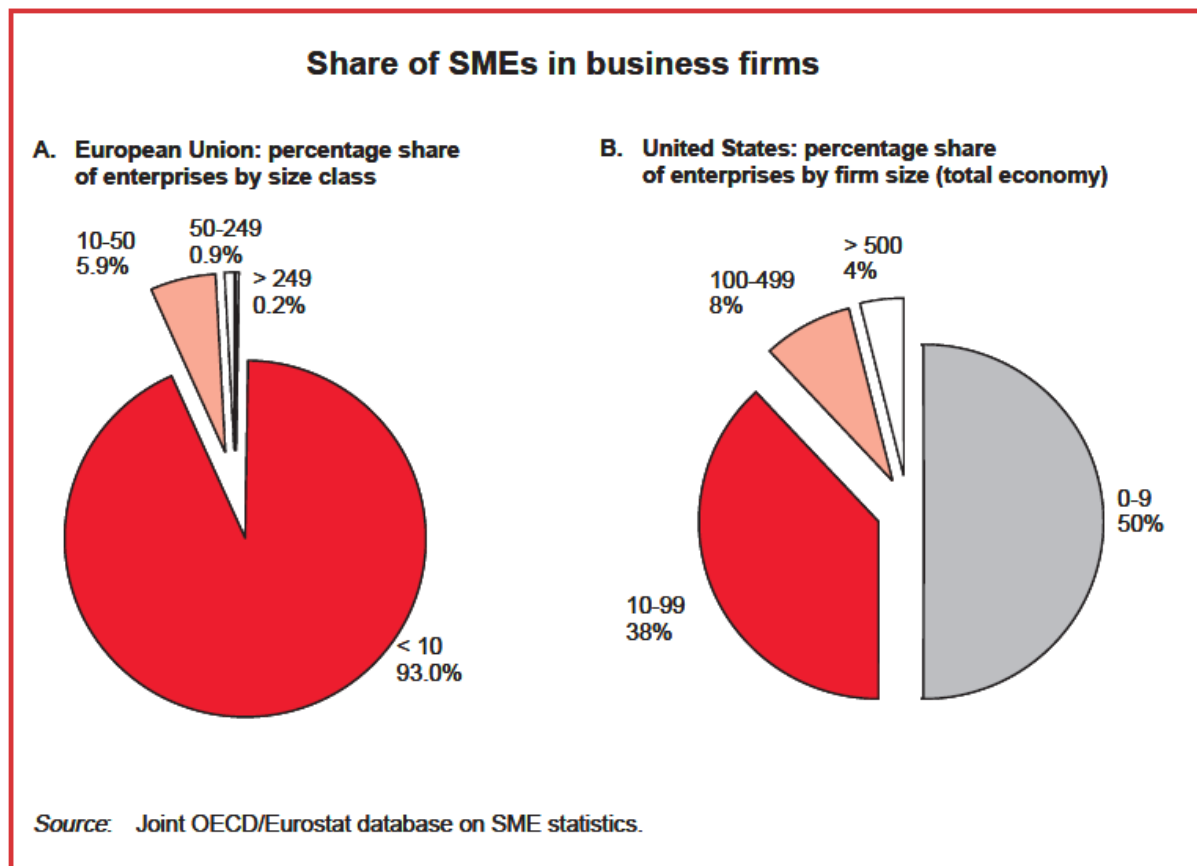


Figure 1- Share of SMEs in business firms [2]

The definition of SME varies by country, but the language used for definition of SMEs usually is the number of employees and/or their revenue. The EU and most of OECD countries set the upper limit of employees in the SMEs between 200-250, with some exceptions such as Canada and the USA setting the upper limit on 500 employees. SMEs have an important effect on the export revenues in developing countries. Table 1 provides information on the SME shares of manufacture exports in some countries [3].

Table 1- SME Shares of Manufacture Exports in Developing and OECD Economies [2]

Economy	Year	Definition of an SME (a)	% SME manufacture exports
<b>Developing Economies</b>			
Chinese Taipei	Early 1990s	<100 employees	56
China	Early 1990s	<100 employees	40-60
Korea	1995	<300 employees	42.4
Vietnam	Early 1990s	<200 employees	20
India	1991/1992	<Rs 30 M investment in plant & machinery	31.5
Singapore	Early 1990s	<100 employees	16
Malaysia	Early 1990s	<75 employees	15
Indonesia	Early 1990s	<100 employees	11
Thailand	Early 1990s	<100 employees	10
Mauritius	1997	<50 employees	2.2
Tanzania	2002	<50 employees	<1.0
Malawi	2003	<50 employees	<1.0
<b>OECD</b>			
Denmark	Early 1990s	<500 employees	46
France	1994	<500 employees	28.6
Sweden	Early 1990s	<200 employees	24.1
Finland	1991	<500 employees	23.3
Japan	1991	<300 employees	13.3
USA	1994	<500 employees	11
Average for 6 OECD countries			24.4
Note: (a) Definition adopted by each study, which may be different to the official national definition of an SME.			
Studies: Korea (Kim and Nugent, 1999), India (Badrinath and Others, 1997), Mauritius (Wignaraja and O'Neil, 1999), Tanzania and Malawi (estimates based on Wignaraja's fieldwork), the remaining countries (OECD, 1997).			

According to Srpová (2010), management of SMEs has some specifics [4]. In small companies, many functions are accumulated within few competence workers. Informal leadership and oral communication, etc. can be seen in SMEs.

Although new technology had a positive impact on the SMEs, many of traditional issues faced by SMEs and impacting their growth still needs to be improved [2]. Of such we can mention to some of them in the following:

- Financing issue: as for finance issue we can consider some of the following items:
  - ✓ Lack of money to invest on new technology
  - ✓ Lack of money to hire competent resources
  - ✓ Lack of money to invest on purchase of new equipment
  - ✓ Lack of money to construct or purchase a bigger working area or expanding the existing working area, and so on.
- Difficulties in implementing technology due to lack of skilled resources and/or not being able to outsource the implementation of their technology
- Constrained managerial capabilities for not being able to pay high skilled managers
- Inefficient productivity
- Regulatory burdens, etc.

Among challenges mentioned above, finance and inefficient productivity can be considered as two of the most important ones that slowdowns the growth of SMEs. Owners of smaller firms often do not have enough knowledge or experience about marketing or commercial. Also, some small firms have difficulty in obtaining financing since the banks are not willing to invest of risky companies [2].

However, to increase the profit of a company, necessary for their growth, we can either increase the revenue or decrease the expenses. As I said most of the SMEs has difficulty in increasing their revenue from their commercial end, so the objective of this project is to help them improve their finance issue by developing a workflow model using the Environment Based Design (EBD) methodology. The purpose is to reduce the expenses of a company by increasing the operation and production efficiency and effectiveness.

The industry under consideration is a medium-sized enterprise, manufacturing complex refractory lined FCC equipment. Valtech Fabrication Inc. (Valtech) was founded and incorporated in June 2000. It is a custom metal fabricator for various end-markets, with expertise in fabricating and manufacturing for oil refineries. It provides several products and services, including fabrication of Cyclones, Air Distributors, Riser Lines and other complex refractory lined FCC equipment. As Valtech has dedicated to providing a quality product and service, it has a rapid growth. In a relatively short amount of time, Valtech Fabrication has become an internationally recognized Custom Metal Fabricator. In order to adapt to this fast growth, in October 2015, Valtech launched an information management system – Epicor system to manage all the resources of Valtech of its business, including production. The Epicor system has brought a significant change to Valtech. It has not only improved the business operation, but also brought challenges to Valtech in adapt to the transformation. There is a definite need to optimize certain functionalities to further capture sought-after synergies. As well, and as was expected, the introduction of the ERP system has given rise to new challenges; challenges that need to be properly understood and addressed. As Valtech's business has grown significantly, it has a pressing demand on the innovation and optimization of its business procedures and process, including production. As introduced, the application of Epicor ERP system has led to new challenges in the process of operation. They need to be studied and addressed in a professional and systemic way.

## **Motivation**

Workflow innovation [5] is a critical issue for almost every agency in the business operation [6]. Innovation lies at the heart of a nation's economy. EBD methodology and performance model

could greatly enhance industry's capabilities and capacities in producing creative and innovative services [7,8]. It is supposed that the proposed project will not only help Valtech to improve the workflow but will also contribute toward improving the performances of other companies or agencies facing the similar situations. The successful application of this project will greatly benefit Canadian industrial sectors. EBD as will be explained in chapter 3 of this paper is a technique conducting deep investigation in environment to understand the problem and find the main causes of the problem. To solve a problem is very important to understand the problem and whatever affected the problem to be able to provide an effective and efficient solution and EBD is a technique helping us to achieve this goal.

## **Contributions**

There are so many factors that affect how quickly a business grows and efficiency can be considered one of the most important ones. For example, the difference between companies that use paper-based processes versus completely digital ones is obvious. To improve business and compete in today's market, there is a need to have a process that ensures the quality of products, ease of use of the process, and profit for the business. Quality of the products is necessary to have satisfaction of the clients and keep the reputation of the business, while profit is vital for business to continue their work.

One solution for improving the business process management is undoubtedly benefiting from workflows. An effective workflow helps to grow the business by providing the framework through which all tasks are done. Workflow helps with understanding of how the processes work and the



way of their functions. This can lead to better decision making, reducing the wastes and cost, increasing the profitability and efficiency. More details can be found in chapter 2 of this paper.

The EBD methodology is explained in the methodology section. This is followed by the illustration of how to apply EBD to develop a workflow model.

In addition, the Master student, the author of this paper, worked at Valtech site. It was expected that the developed workflow model could be embedded in Valtech's operation processes.

The main contributions of this thesis include the following:

- Model of the existing operations workflow through collecting and analyzing the field operations data.
- Optimized workflow model by applying EBD methodology.
- Implement and improve the workflow model.

## **Thesis Organization**

The rest of the present thesis is organized as follows:

- Chapter 1 INTRODUCTION: introduction of the background, motivation and contributions;
- Chapter 2 WORKFLOW MODELING: introduction of the workflow modeling and techniques that can be used to design a workflow.

- Chapter 3 APPLICATION OF EBD TO DEVELOP THE WORKFLOW MODEL: 1) explanation of why EBD can be used to develop the workflow model, and from general point of view, 2) explanation of how to apply EBD to develop the workflow model step by step: understanding design problems, analyzing design problems, and then solving design problems.
- Chapter 4 MODEL VERIFICATION: review of the case study including an additional introduction and analysis.
- Chapter 5 CONCLUSIONS AND MOVING FORWARD: concluding remarks about Valtech workflow model and recommendations.

# Chapter 2

## **Modeling Business Process Workflow: Literature Review**

Business process modeling is the activity of representing a company's business processes or workflows graphically, as a means of identifying potential improvements [9]. This can be done using different graphing methods, such as the Business Process Modeling Notation. Business process modeling helps with understanding of how the processes work and the way of their functions. This can lead to better decision making, reducing the wastes and cost, increasing the profitability and efficiency, and so on.

There are three types of business processes [9]:

1. Operational processes are the core of the business where starts from order from client to manufacturing a product.
2. Supporting processes which support the operational processes
3. Management processes is where the managers work on efficiency and effectiveness of operational processes to make sure the operational processes are done properly and to the satisfaction of clients.

Process is defined as a set of activities designed to achieve a particular end. Two states of the process are the target points of Business process modeling:

1. The state of the process as it is right now: this gives us an idea where we stand, and what are our weaknesses and strengths.

2. The future state, after making the changes: before making the changes, we can have an overview of how the process looks like after the changes, by looking at the graphic model.

## **1. Benefits**

In below I try to brief some of the most popular and known benefits of Business Process modeling [9].

### **1.1. Improving Efficiency**

As mentioned above, improving efficiency is one of the most important functions of Business Process model. It gives us the availability to find different ways of improving the process, which leads to higher efficiency, productivity, and profitability.

### **1.2. Standardization**

Creating the procedures and standardizing them ensures that everyone knows how to do the process.

### **1.3. Process Agility**

Business Process modeling aid the managers to apply changes in the system and to be able to evolve in the face of technological change.

### **1.4. Beat the Competition**

To compete in today's world, every organization needs to be improved. Business Process modeling gives us the capability to beat the competition and outlast in the long run.

## 2. Techniques

Below are some of the most common techniques in designing the business process models [10]. Any of these techniques can be used to design a workflow and there are so many articles that benefited from these techniques for different scenarios. However, in this paper, I will use Environment Based Design (EBD) method for its privilege in doing deeper environment analysis to find the main reasons for the causes to address them properly and solve the problems permanently. To make it clearer and understandable let's consider this imaginary example. In a company there is an issue of losing parts and we have to spend lots of time finding the parts. So many internal solutions proposed by senior managers, but none worked. A research can be conducted by an external consultant using one of the techniques explained in this chapter to design a workflow and provided as a solution, but that may never work since the main cause of this issue is not because of the lack of workflow or not having a tracking system, but for not respecting the system and work of others by one of the owners who takes care of the production. He never puts back the things to their place after use and never register the new location of the pieces in the system after moving, and the managers working close to him, never address this to the higher managers and/or the CEO since he is one of the owners. Replacing him with a well-experienced manager can solve this problem permanently and this can never be addressed by a workflow. It does not mean that these techniques never provide an effective solution, but as I said the privilege of EBD comparing to these techniques is to do deeper environment analysis to find those probable main causes.

## **Business Process Modeling Notation (BPMN) [11,12]**

BPMN is a standard for business process modeling using graphical representation for specifying a business processes in a model. The primary goal of BPMN is to provide notation understandable by all business users and managers and give organizations the ability to communicate in a standard manner.

There are three types of BPMN models:

- Private business processes are type of processes that called workflow. The sequence flow of the process will remain inside the boundaries and only message flow can pass the boundaries to show the interaction exist between the private business processes.
- Abstract processes are the interactions between the private process and other processes. The activities that are outside of the boundaries of the private processes are covered by Abstract processes.
- Collaboration processes are the interactions between business entities.

Figure 2 represents the example of a collaboration processes model.

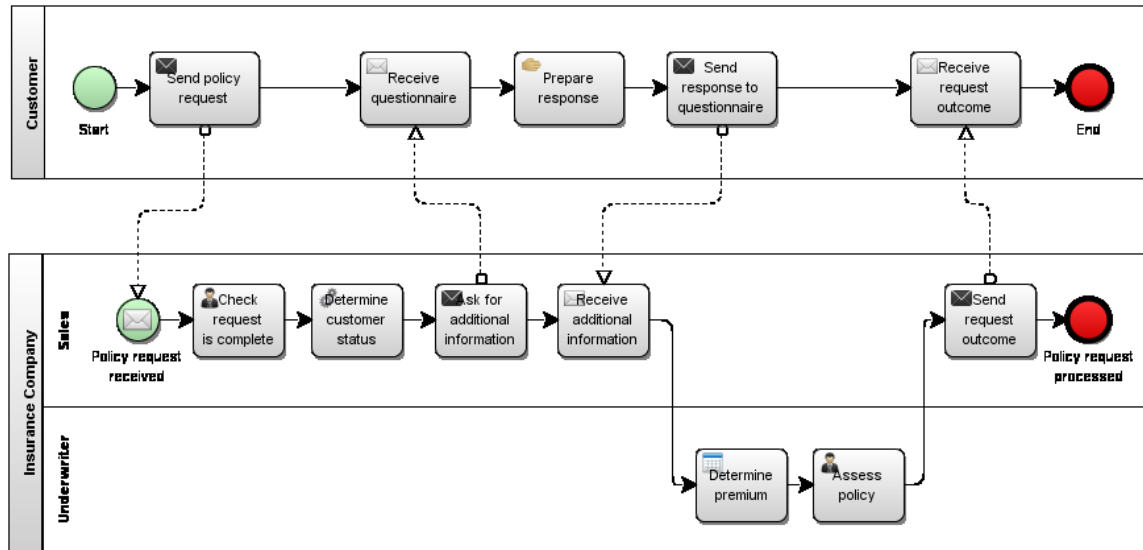
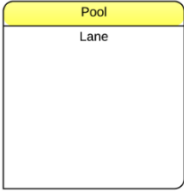
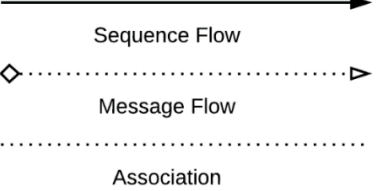


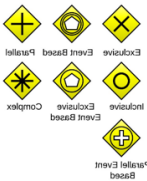


Figure 2- BPMN Collaboration Processes Model Representing E-Mail Voting Process [11]

To develop a BPMN diagram, creating a simple mechanism is essential. Elements categories, flow objects, connecting objects, etc. are cores of BPMN. Table 2 shows the categories essential for creating a BPMN diagram.

Table 2: Categories for Creation of BPMN Diagram

Categories for creation of BPMN diagram							
Swim Lanes		Connecting Objects			Flow Objects		
Pool	Lane	Sequence Flow	Message Flow	Association	Events	Activities	Gateway
							
Pools and lanes are also two ways of grouping the modeling elements		Sequence flow, message flow, and association are three ways of connecting the flow objects			Event is something that happens during a business process	Activity is a generic form for work the company performs	Gateway is used to determine the branching, forking, etc. to control the flow

Flow objects are the main elements to define the business process and are in the forms of events, activities, and gateways.

Event is something that happens during a business process and has impact on the flow of the process.

Activity is a generic form for work the company performs and can be atomic or non-atomic.

Gateway is used to determine the branching, forking, etc. to control the divergence and convergence of the flow.



Sequence flow, message flow, and association are three ways of connecting the flow objects. Pools and lanes are also two ways of grouping the modeling elements.

Start, intermediate and end events show the workflow and activities of the processes. Connections will connect all the events to shape the diagrams and give path to them.

The example of an BPMN diagram is shown in Figure 3 representing E-Mail voting process.

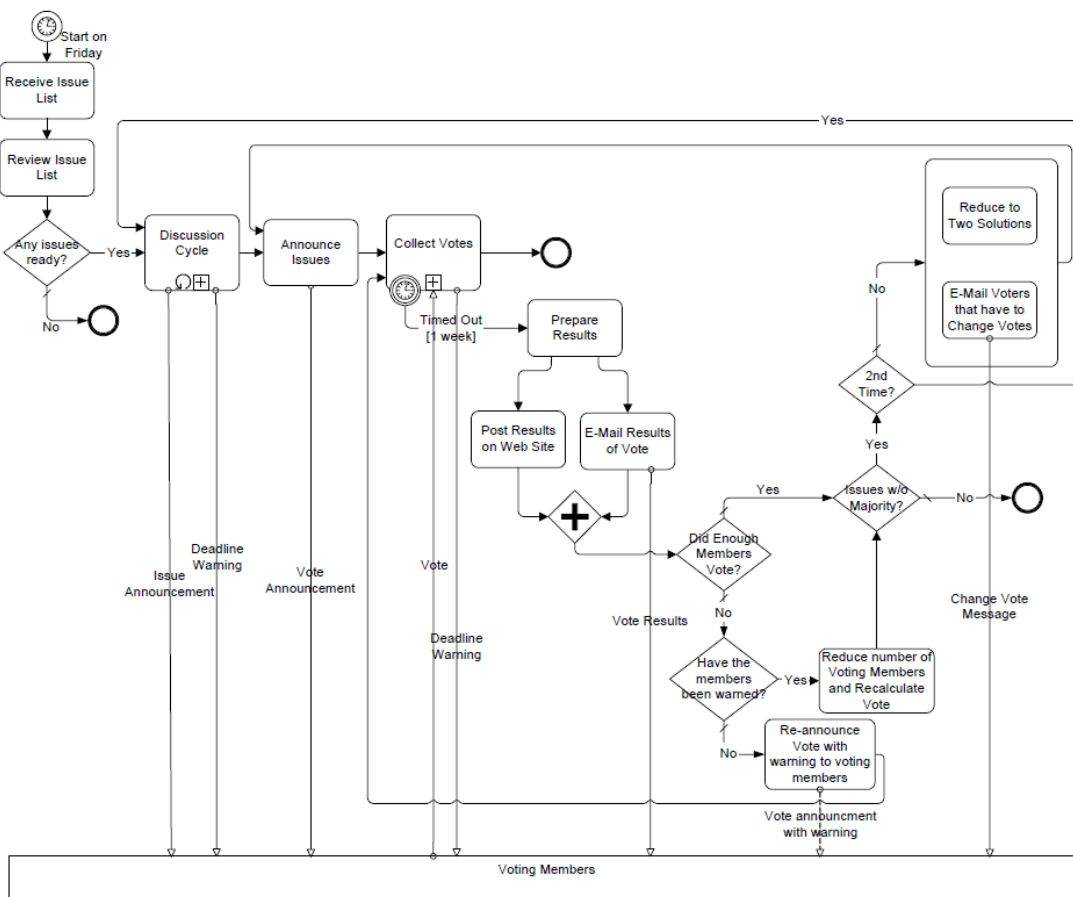


Figure 3- BPMN Diagram Representing E-Mail Voting Process [11]

## Unified Modelling Language (UML) [13]

UML is a modeling language designed by software developers, but it can be used for business process modeling. UML is intended to provide a way for specifying, visualizing, and documenting the design of a systems. It was developed later by the Object Management Group (OMG) and has been controlled by them. UML diagrams represent static view, and dynamic view of a system by emphasis on static structure of a system and the dynamic behaviors of the system respectively.

Figure 4 shows the example of UML diagram.

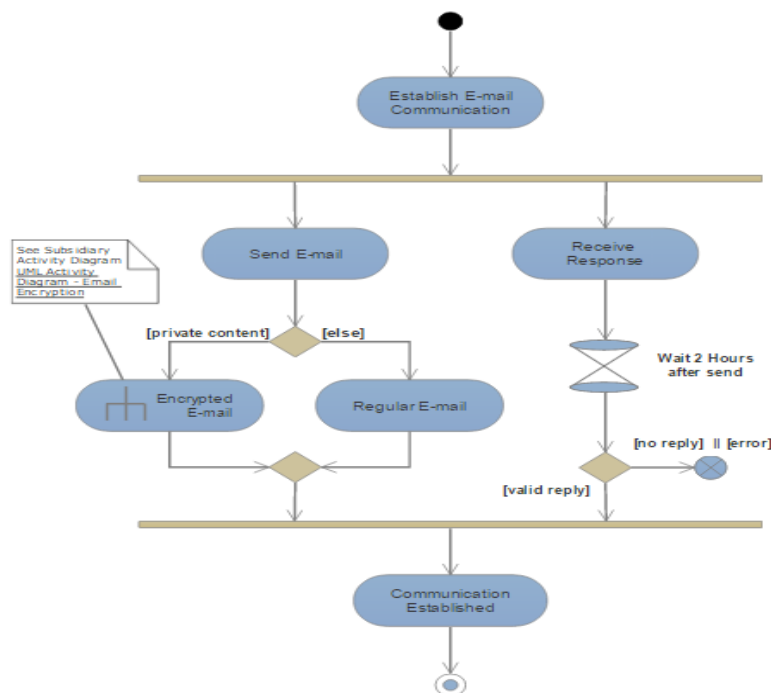


Figure 4- UML Diagram [13]

## Petri Nets and Colored Petri Nets (CPN) [9]

CPN is a graphical oriented language for design, and verification of systems. Figure 5 shows a Colored Petri Nets diagram.

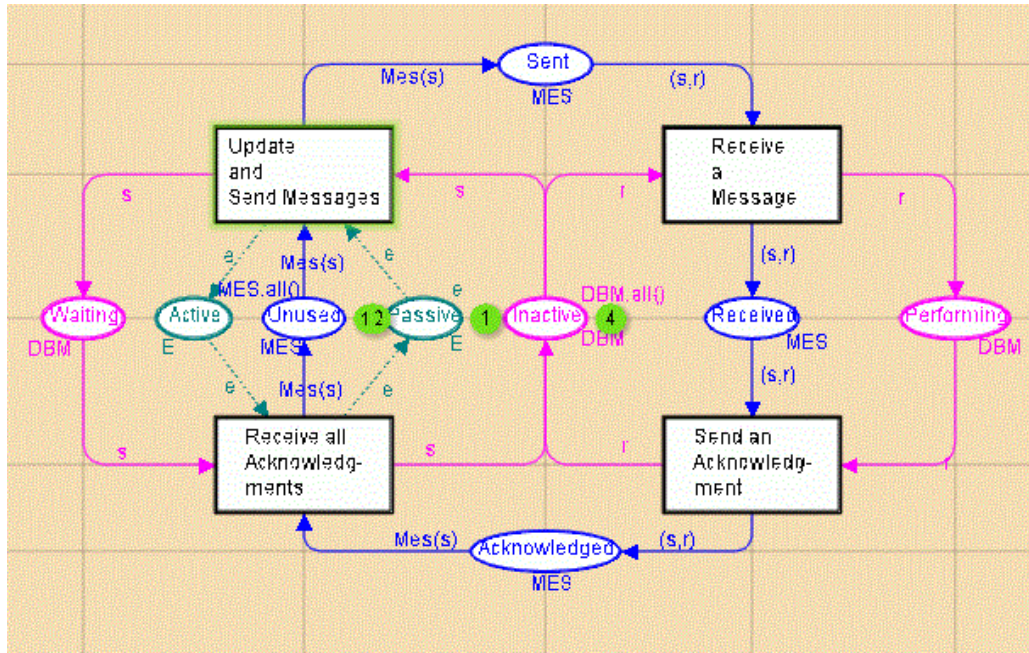


Figure 5- Colored Petri Nets Diagram [9]

### Flowcharts [9]

It is a graphical representation that symbols are used to represent operations, data, and equipment to define, or analyze a problem. Flowcharts were used long before new techniques such as BPMN, or UML. Figure 6 shows an example of flowcharts.

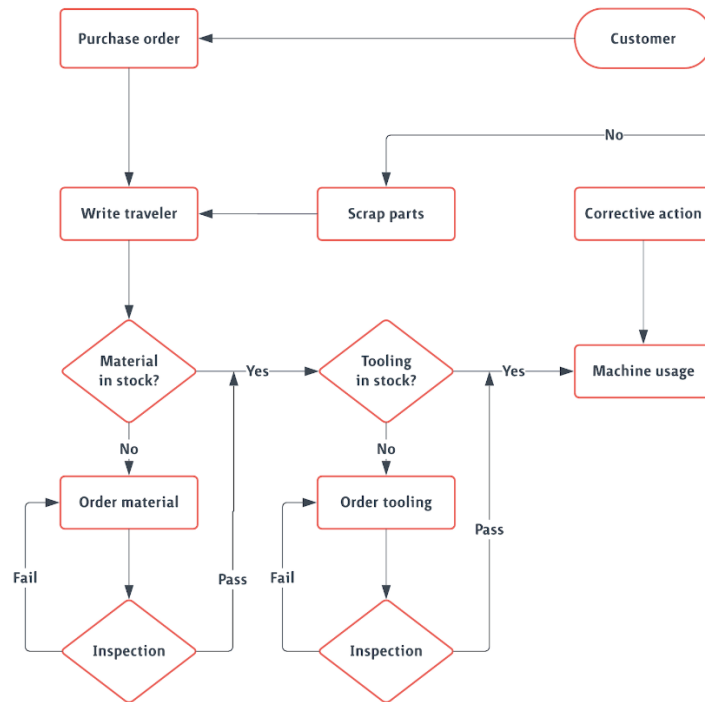


Figure 6- Flowcharts [9]

### Yourdon's Data Flow Diagrams (DFD) [9]

Data flow diagrams (DFD) are diagrams that show the flow of data or information. They are used to record the processes analyses. Figure 7 shows an example of a Data Flow Diagram.

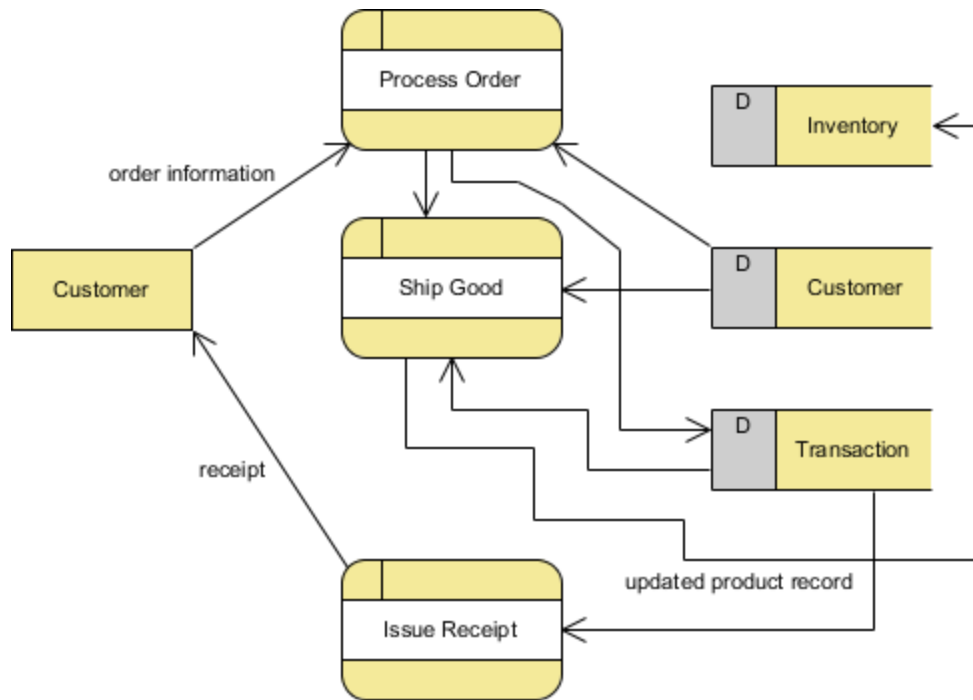


Figure 7- Data Flow Diagram [9]

### Integrated Definition for Function Modeling (IDEF0) [14]

IDEF0 is a modelling technique used for developing of processes or complex systems. IDEF stood for Integrated Computer Aided Manufacturing (ICAM) and developed in sixteen series for different functions. However, IDEF0 is designed to model the actions, or activities of a system or enterprise. Figure 8 shows an example of an Integrated Definition for Function Modeling.

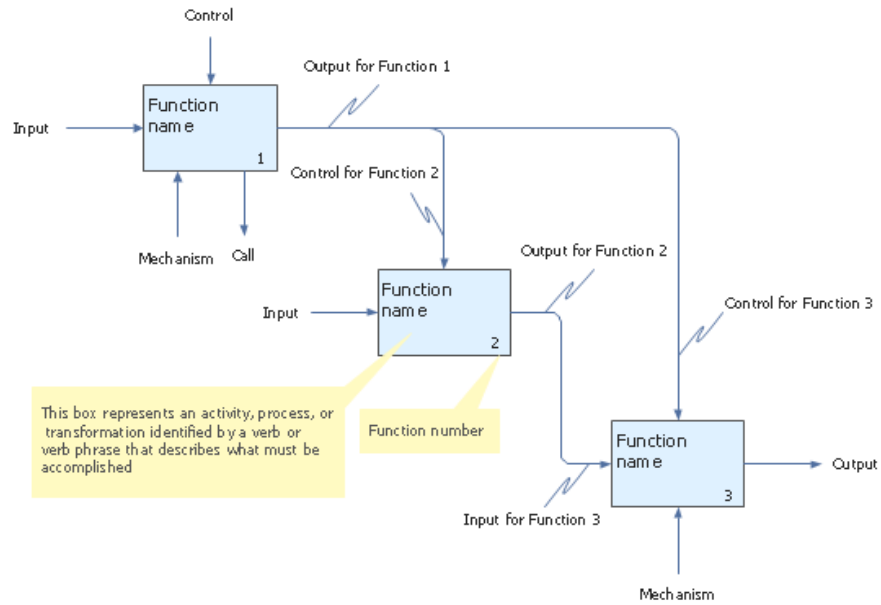


Figure 8- Integrated Definition for Function Modeling [14]

## Gantt Charts [9]

Gantt Chart is a matrix that lists the activities to be performed in a process. Figure 9 shows an example of Gantt charts.

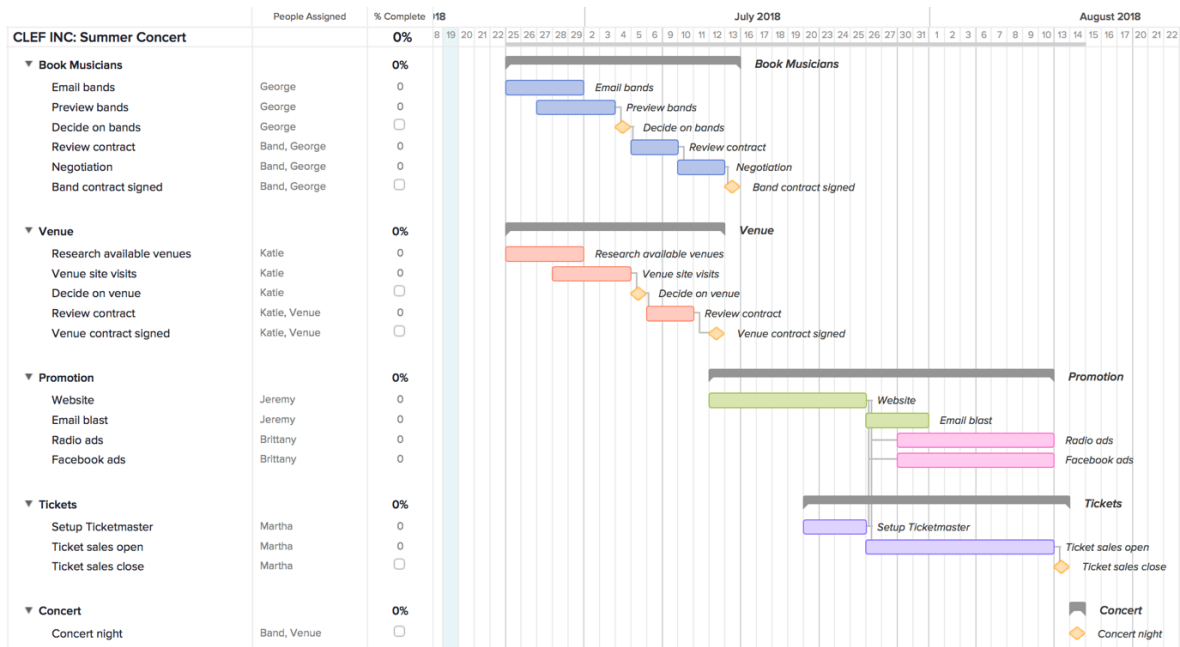


Figure 9- Gantt Charts [9]

## Chapter 3

### EBD Approach to Developing Workflow Model

With the background introduced in Chapter 1, the knowledge of process workflow modeling in Chapter 2, now in Chapter 3, will introduce:

- Why EBD is recommended to develop workflow model
- How to apply EBD in developing a workflow model.

An example from Valtech is used to show how to use EBD from general point of view:

"we have a big problem in material department that we don't have a fixed place for reception and always people spend lots of time finding the received material at the time they need them and in warehouse we have no tracking system or responsible to control the material. We wanted to solve this problem"

The detailed development is shown in the next chapter. In this Chapter the concept design and the advantage of applying EBD is shown. Figure 10 shows an ROM designed for the above-mentioned example from Valtech and will be explained more in detail later in this chapter.



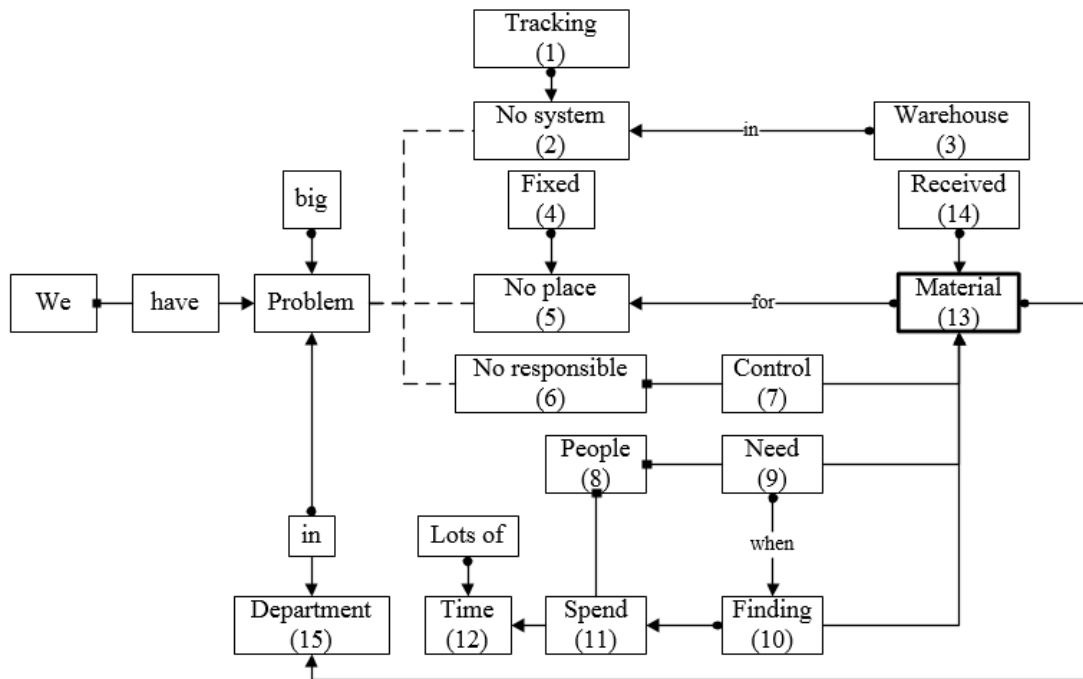


Figure 10- ROM

## Overview: Why EBD in Developing a Process Workflow Model

In the following we see how usually people solve a problem. Figure 3 shows three steps in solving a problem.

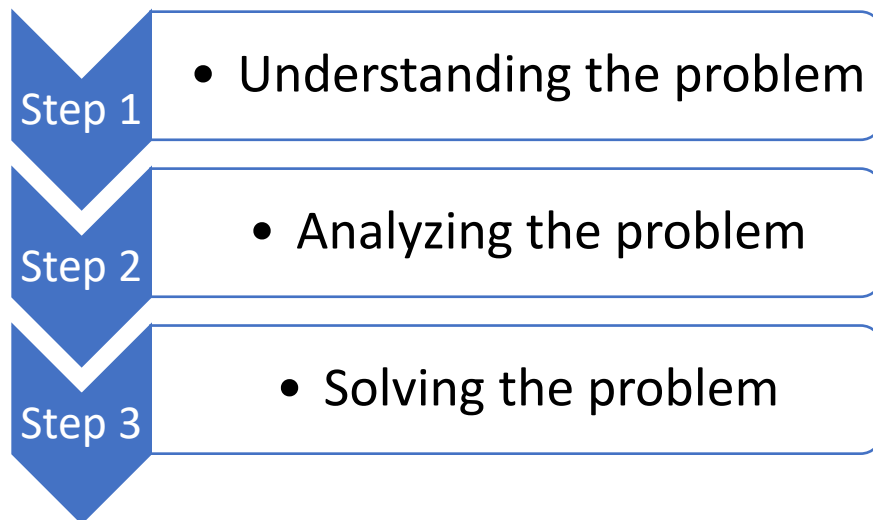


Figure 11- Problem Solving

However, people often fail at the first step of understanding the problems. Figure 12 shows how important it is to understand design requirements correctly.

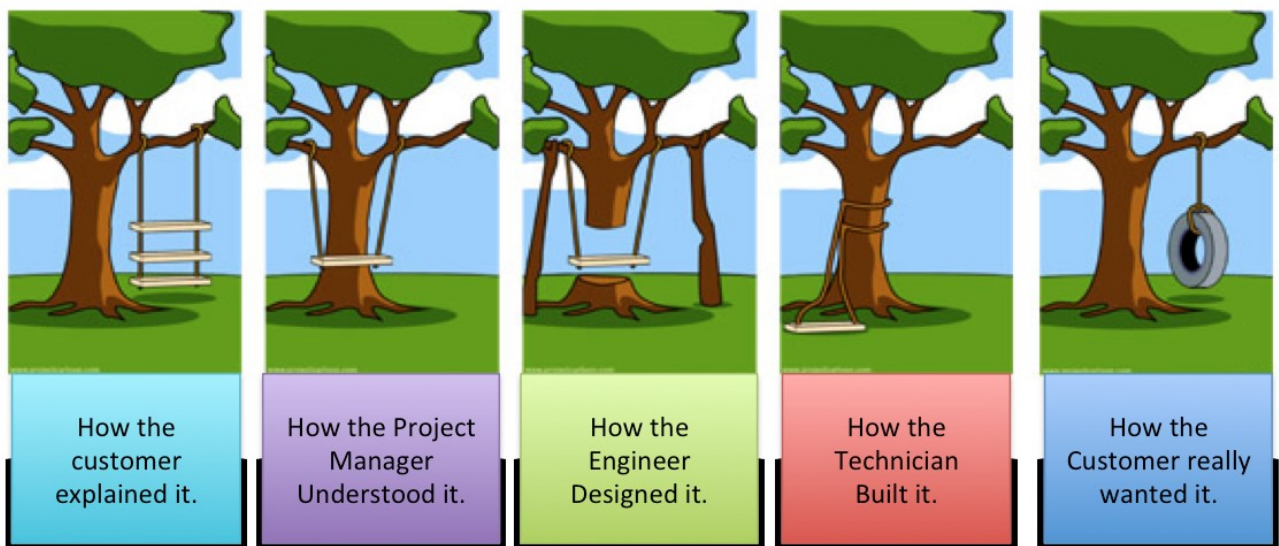


Figure 12- Illustration of Problems [15]

The EBD is different from other techniques, explained in chapter 2 of this thesis, by its emphasis on environment analysis to understand the problem to be able to develop a flexible and reliable workflow model. Other techniques as explained in chapter 2 are useful to design a workflow but are not designed to do environmental analysis. The EBD is more concentrated to environment and starts by analyzing the environment to find out what impacted the environment and caused an issue.

In the following we learn more about EBD.

EBD is a method that help designers to solve a design problem. EBD consists three major steps: environment analysis, conflict identification, and solution generation. It observes the environment followed by the recursive nature of design to obtain the design solutions effectively and efficiently. Recursive Object Model (ROM), performance network, conflict network, etc. are the tools for conducting the above-mentioned steps of EBD in process designing.

## **Environment Based Design and its Fundamentals**

Environment-based design (EBD) is a design methodology derived from the axiomatic theory of design modeling [16,17] starting with environment design. It provides step-by-step guidance for designers from the collection of necessary and sufficient information from environment for a design task throughout the generation of design requirements in an efficient manner. The underlying principles behind the EBD are that design comes from the environment, serves the environment, and return to the environment [18].

The EBD includes three basic activities illustrated in the figure 13: environment analysis, conflict identification, and solution generation. These three activities are interdependent, and they work together to generate and refine the design specifications and design solutions.

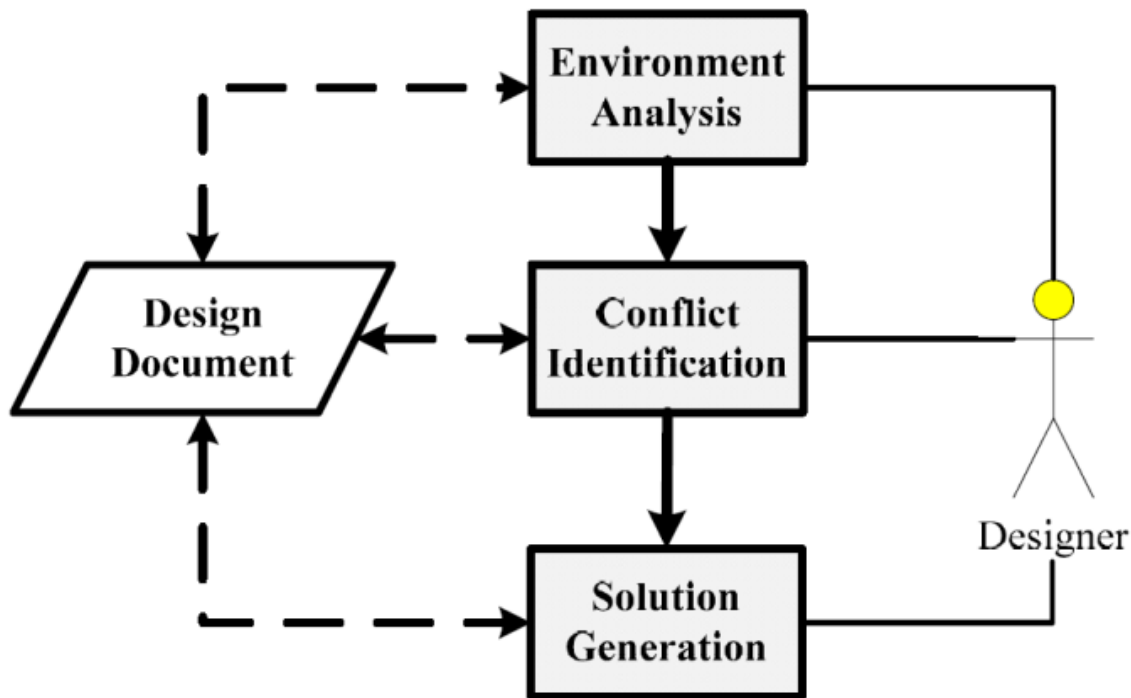


Figure 13- Environment-Based Design: Process Flow [19]

The three activities will be explained in more detail.

## 1. Environment Analysis

The objective of environment analysis is to find 1) the components, in which the desired product works, and 2) the relationships between the environment components. All product requirements come from the environment, so it is obvious that identifying the environment components is essential for the success in design. From the problem description by the customer, the designer will add new components that are relevant to the problem. In the environment analysis section, the

designer tries to know as much as possible about the root causes of the problem by breaking down the environment system to sub-systems. Decomposition of components continues until these components are proper for defining the current environment system. Recursive objective model and question asking strategy are two essential tools in this purpose [20].

### **1.1. Asking the Right Question**

Asking proper questions in collecting data and information from customer is critical for the product that is to be designed. Any design process starts by description of a problem by customer. Customers usually describe the problems in natural language and asking the right questions is the way to generate and structure the provided descriptions. By asking the questions, the real intent of the customer and more complete list of product requirements will be defined. Figure 14 shows the question generation process in environment analysis. The process of environment analysis can be divided into eight steps as follows [20].

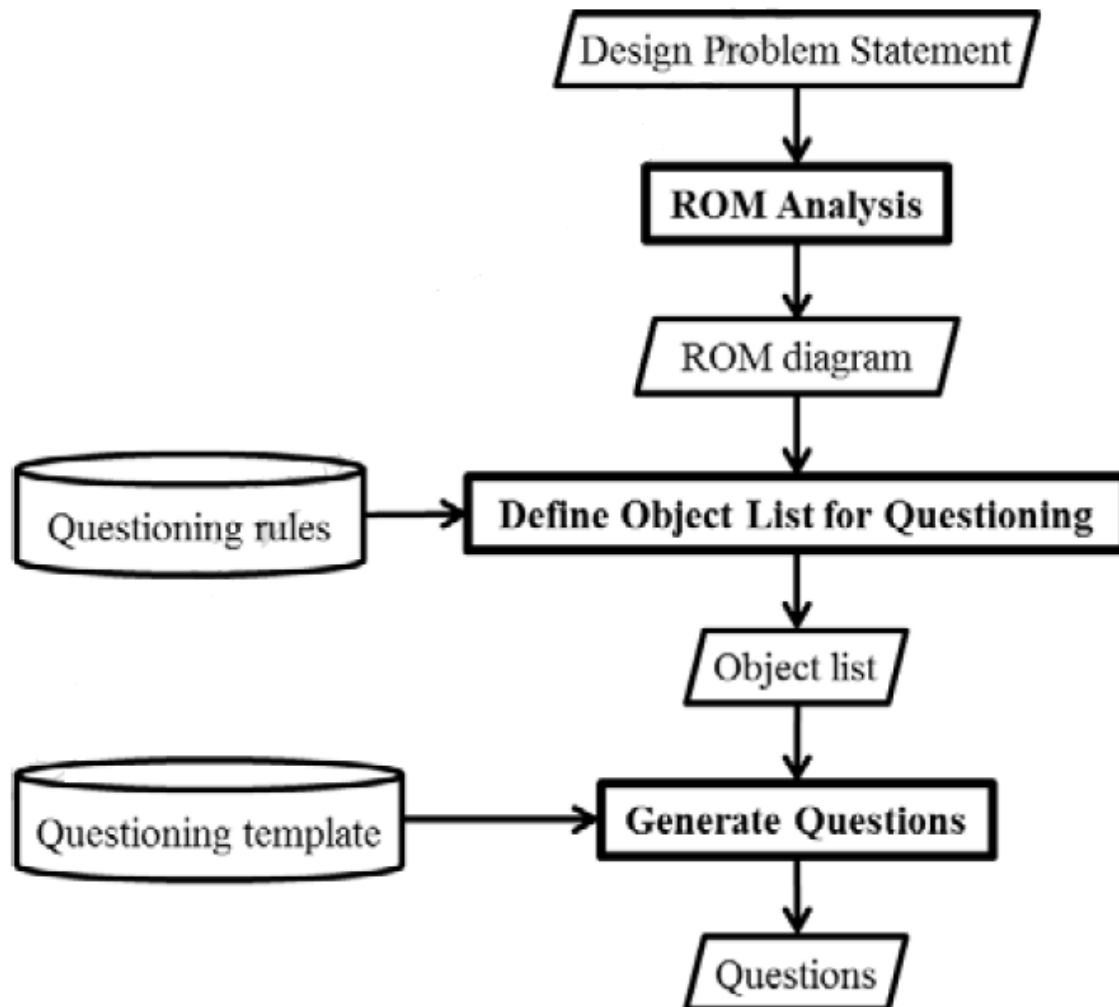


Figure 14- Question Generation Process in Environment Analysis [20]

Step 1: create a ROM diagram

The designer creates the original design problem based on the description provided by the customer.

There are two types of questions to be asked based on the developed ROM diagram: generic question, and specific questions.

The target of generic questions is clarification and extension of the meaning of the design problem whereas the specific questions are for implicit design information.

## Step 2: Generate generic questions

The designer will generate the right questions to be asked following the analysis of all the objects in the ROM diagram. This will be done in four steps:

Step 1: Code objects in ROM. Figure 15 shows an example of ROM with codes.

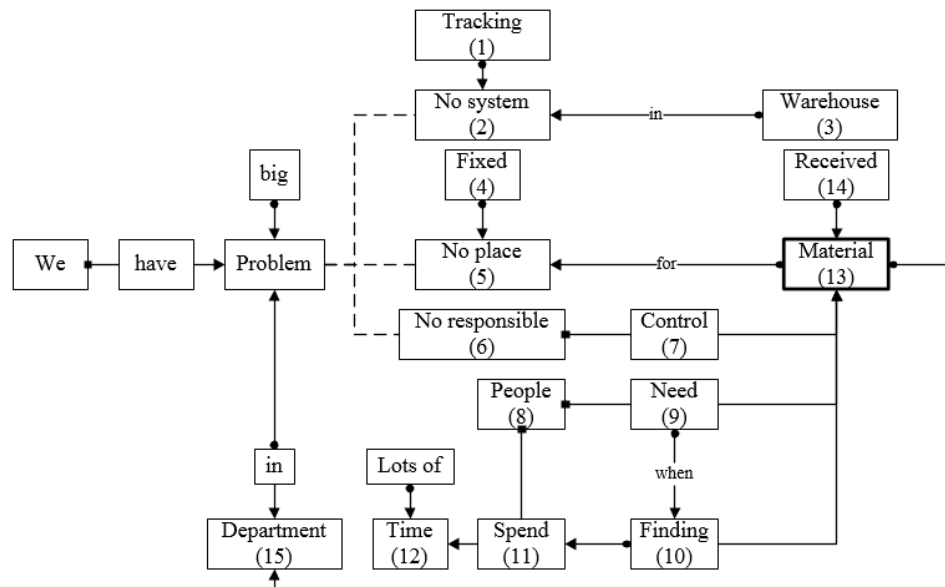


Figure 15- ROM

Step 2: Construct ROM matrix. Figure 16 shows an ROM Matrix. ROM Matrix finds out the number of relationships between the codes of step 1. Rows and columns are the codes defined in step 1 and the numbers in the matrix are the relationship and connections of those codes together.

Number 1 means objects i and j have a subject-verb relation.

Number 2 means objects i and j have a verb-object relation.

Number 3 means objects i and j have a constraint relation.

Number 0 means otherwise

		1	2	3	4	5
1						
2						2
3		1		1		
4			3			2
5				3		2

Figure 16- ROM Matrix

Step 3: Rank ROM objects. Figure 17 shows an example of how to rank the objects of the ROM diagram. The number of relations comes from the number of connecting lines to each object. In chapter 4 all the steps are done for a real problem.



Number of relations	3	2	1
Object	5	3	1, 2

Figure 17- ROM Object Ranking

Step 4: Define object list for questioning: rules in Table 2 have to be applied to find the order of questioning objects. [20]

Table 3- Rules for Finding Objects to Question [20]

Rule 1	Before an object can be further defined, the objects constraining them should be refined.
Rule 2	An object with the most undefined constraints should be considered first.
Rule 3	If an object has the most number of constrains and/or predicates on other objects, then it should be considered first.

Step 3: collect answers

The designer collects the answers that are generated in step 2. This can be done using a dictionary or from the information provided by customer.

Step 4: repeat step 1 to 4 until no more generic questions can be asked

Step 5: generate specific questions

Doing the first four steps, the ROM diagram will be more clearly shown the description of the procedures. In this step, the designer needs to draw out more environment information about the

design problem, so the designer analyses the relationships between the objects of the ROM diagram and generates a set of specific questions to be answered at each stage of the design.

Step 6: collect answers to the specific questions

Step 7: repeat step 1 to 7 until no more questions can be asked






Step 8: output the updated design problem description

In this step, the description of the problem is clearer to the designer. As a result, the designer will concentrate and work on the real problem which can be totally different from the one described at the beginning by customer.

## **1.2. Recursive Objective Model (ROM) [21,22]**

The recursive object model (ROM) is a part of the EBD theory in modeling the description of the problem. It is a graphic language used as an intermediate medium between natural language, provided by customer, and structured modeling language. As shown in the Table 3, the ROM is composed of five elements, including two objects and three relationships. The objects and relationships will be used in ROM diagram with their symbols to represent the objects and the relationships between them.

Table 4- Elements of Recursive Object Model [21]

Type	ROM symbols	Description
Object		Everything in the universe is an object.
Compound Object		It is an object that includes at least two objects in it.
Constraint Relation		It is a descriptive, limiting, or particularizing relation of one object to another.
Connection Relation		It is to connect two objects that do not constrain each other.
Predicate Relation		It describes an act of an object on another or that describes the states of an object.

## 2. Conflict Identification [20]

Conflicts may be identified following the update of ROM diagram that is developed in environment analysis [18]. Conflict identification helps to find undesired conflicts between environment components and the relations between them. There are three form of conflicts: conflict between two objects, between two constraint relations, and between two predicate relations as shown in Figure 18.

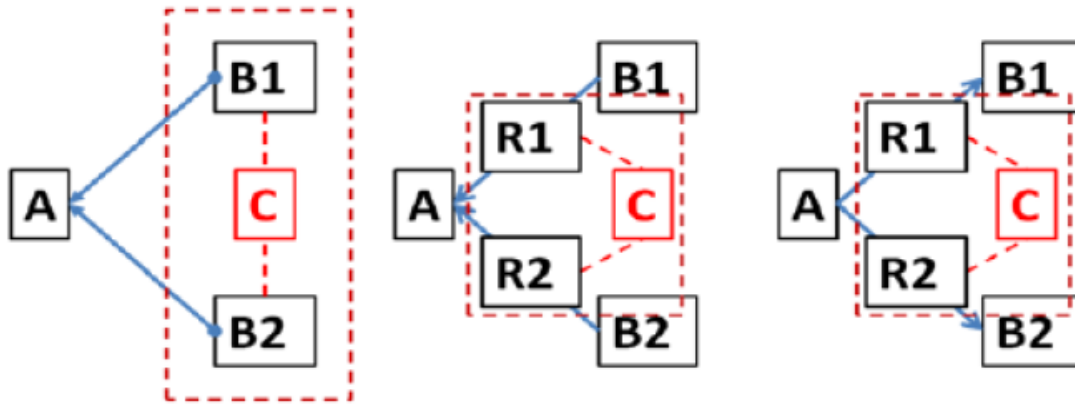


Figure 18- Three Rules for Conflict Identification from a ROM Diagram [20]

Table 4 shows three rules for the identification of potential conflicts from a ROM diagram.

Table 5- Rules for Identifying Potential Conflicts [20]

Rule 1:	If an object has multiple constraints, then potential conflict exists between any pair of constraining objects
Rule 2:	If an object has multiple predicate relations from other objects, then potential conflict exists between a pair of those predicate relations
Rule 3:	If an object has multiple predicate relations to other objects, then potential conflict exists between a pair of those predicate relations

Using Figure 15 as an example gives us the following interactions:

- I1: Received material has no place
- I2: Warehouse has no tracking system
- I3: People need to find the materials
- I4: Warehouse has no responsible person

Table 6 shows the casual relationships between interactions:

Table 6- Casual Relationships Between Interactions

	I1	I2	I3	I4
I1	0	0	1	0
I2	0	0	1	0
I3	0	0	0	0
I4	0	0	1	0

Figure 19 shows the performance network designed based on the information from Table 5 to find the undesired conflict. As it is evident from the Figure 19, the interaction 3 is the critical conflict that has the most influence on the other interactions and needs to be solved prior to the other conflicts. It will be considered as a root conflict.

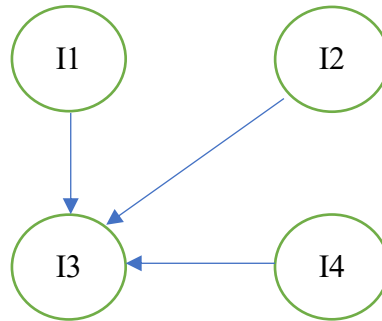


Figure 19- Performance Network

### 3. Solution Generation

It is very important to find root conflicts before generating solutions since the main goal of the design solutions is to satisfy the requirements of solving the root conflicts, so firstly the designer

should analyze the data obtained from ROM to identify the root conflicts. The root conflicts have influence on the other conflicts that this influence can be direct or indirect or the combination of both. Resolving the root conflicts may eliminate the number of conflicts that are dependent to them. The generated solution becomes part of the new environment for the succeeding design and the ROM diagram needs to be updated. This process continues until no more undesired conflicts exist. From Figure 19, the designer will generate a solution to solve the interaction 3 in priority to other conflicts. This design may address the other conflicts to solve all at the same time, that can be considered as a successful case, however, the solution may cause new conflicts. In the Valtech case, we could see in 2015 they generated a solution by implementation of ERP system to solve the conflicts they had at that time, but ERP itself became a new conflict. This can be considered as an unsuccessful case.

### **Relationships Between the Three Activities of EBD**

As explained, the EBD can be divided into three activities: environment analysis, conflict identification and solution generation. These three activities work together to update design specifications and design solutions. Figure 13 shows the relationships between three activities of EBD.

### **Workflow Modeling Using EBD**

To solve a problem and for continuous improvement of a business, we need to have enough knowledge, good understanding of the business and its culture, and the people involved. Workflow undoubtedly is a tool for decision makers in an enterprise by providing a map of the business for

better understanding the status of existing issues and missing connections to come up with a better solution. The EBD can be considered as one of the best methods in developing workflow not only for its capability in developing a workflow, but also its emphasis on environment analysis. Environment analysis is important to consider almost all the elements, which affects the environment, causes an issue to end up with a solution permanently and solving it from its root. Figure 20 shows the steps in designing a workflow using EBD.

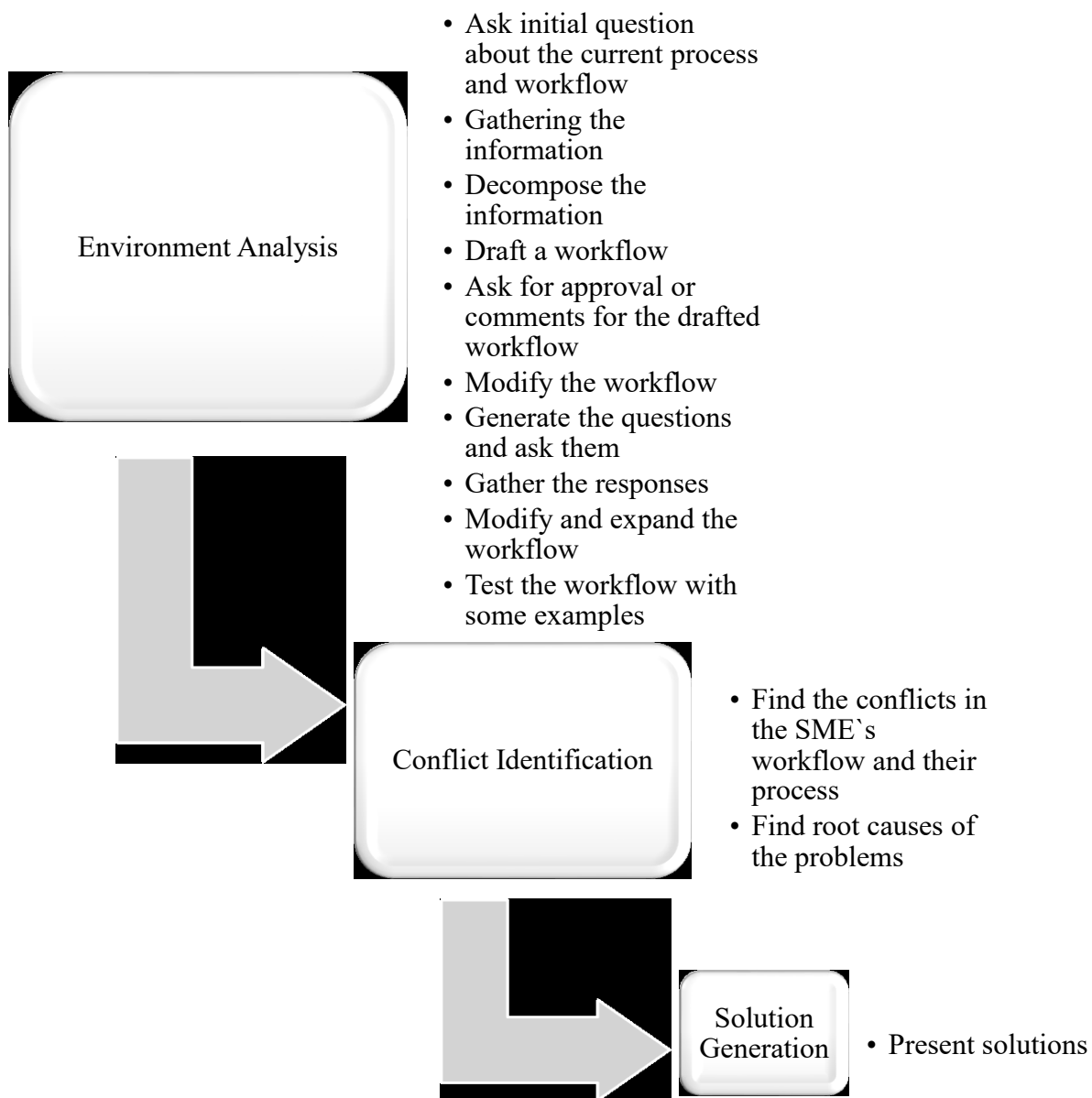


Figure 20- Steps in Designing a Workflow Using EBD



Gathering the initial information from the employees and managers of the company can help to know the environment and get familiar to the environment for better understanding of the problem. Hearing the issues from the owners of the issue is the key point of the EBD. This helps to understand the problem.

In the next step, we will decompose the information and order them in different categories based on the information obtained from the employees and managers. This helps to make the first draft of the existing workflow of SMEs.

Creating the ROM and generating the questions about the drafted workflow is in the next step. Asking the right question is critical since the completed workflow can be very complicated for the owners of the problem. They may not be able to help us making sure if the final designed workflow matches their process.

The generated questions must be asked from the company personnel. It is important to ask the questions from the right person(s).

Based on the answers, the ROM can be expanded adding the obtained information. This can be continued until getting all the required information for developing the final workflow.

Doing some case studies to test the developed workflow before conflict identification can be a good idea but is not mandatory.

After developing the final workflow for an SME, now is time to find the conflicts. The method explained in this chapter must be used to find the conflicts in the model.

Finally, it is time to generate possible solutions and present them to the owners of the SME.

In next chapter, the case study performed at Valtech and step by step guide in use of EBD to develop a workflow is presented.

# Chapter 4

## Case Study

In the following section, a step-by-step guide is presented to show how to apply EBD to develop a workflow model.

### **1. Model Development**

Research team worked on modeling the Valtech workflow and information workflow based on the “Project first transmitted file” and “Epicor ERP Feature Summary”. Valtech workflow refers to workflow addressing the production and Information workflow refers to ERP system that Valtech uses to manage all the resources. In order to model the workflow, the Valtech working steps are decomposed to actions, jobs and conditions that is in section 1.2 of this chapter. Action refers to all the activities to be done in the first phase after having a contract to be prepared for the project. Jobs are the activities to be done in the first phase to prepare what is essential to start a project, and condition refers to different requirements of each project that are different for each project and have to be respected. The decomposition of the Valtech working steps and drafting the workflow model and information model are as follows.

#### **1.1. Current Valtech Working Steps**

The current work process of Valtech is as follows.

Working steps after signing a contract

1. Reading the client specification (different for any client) (Project Manager (PM) and Quality Control Manager (QCM))

2. Preparing the calculation (sometimes we prepare, sometimes comes from client, for expansion joints comes from Valtech Engineering)
3. Preparing the drawings (sometimes we prepare, sometimes comes from client, for expansion-joints comes from Valtech Engineering)
4. Preparing B.O.M (bill of materials) based on the drawings
5. Allocating material to the project (if we have in inventory we use it, if not we buy; however, even if we have in inventory, but we find cheap material in the market (due to any reason) we buy) purchase of material is consist of creating purchase order (P.O) and do the reception by QC (in need I can give information in detail) and etc.(PM)
6. Programming Epicor for that project based on weld joints (PM)
7. Preparing WPS (welding performance specification) if do not have already. (QCM)
8. Preparing procedures for each test such as heat treatment, hydro test, Visual test, etc. (QCM)
9. Preparing ITP (inspection and test plan) (QCM)
10. Holding PIM (Pre-inspection meeting) with client for clarifying their needs (kick off meeting) (sometimes we have, sometimes not) (PM and QCM)
11. Get client approval on all above-mentioned documents after revising based on the comments.
12. Preparing Gantt chart and planning for the project (PM)

## **1.2. Decomposition of Work Process**

Based on “Working steps after signing a contract”, the Valtech working steps are decomposed to sub-steps of Action, Job and Condition (Environment) as following three groups.

### **1.2.1. Action**

1. Reading the client specification
2. Preparing the calculation
3. Preparing the drawings
4. Preparing B.O.M (bill of materials)
5. Allocating material to the project
6. Programming Epicor for that project
7. Preparing WPS (welding performance specification)
8. Preparing procedures for each test
9. Preparing ITP (inspection and test plan) (QCM)
10. Holding PIM (pre-inspection meeting)
11. Get client approval
12. Preparing Gantt chart and planning for the project (PM)

### **1.2.2. Job**

1. Client specification (input)
2. Calculation
3. Drawings
4. B.O.M (bill of materials)
5. Material to the project
6. Epicor for that project
7. WPS (welding performance specification)
8. Procedures for each test

9. ITP (inspection and test plan)
10. PIM (pre-inspection meeting)
11. Client approval
12. Gantt chart and planning (Output)

### **1.2.3. Condition (Environment)**

1. (different for any client) (PM and QCM)
2. (sometimes we prepare, sometimes comes from client, for expansion joints comes from Valtech Engineering)
3. (sometimes we prepare, sometimes comes from client, for expansion joints comes from Valtech Engineering)
4. based on the drawings
5. (if we have in inventory we use it, if not we buy; however, even if we have in inventory, but we find cheap material in the market (due to any reason) we buy) purchase of material is consist of creating purchase order (P.O) and do the reception by QC (in need I can give information in detail) and etc.(PM)
6. based on weld joints (picture 1) (PM)
7. if do not have already. (QCM)
8. for each test such as heat treatment, hydro test, Visual test, etc. (QCM)
9. (inspection and test plan) (QCM)
10. with client for clarifying their needs (kick off meeting) (sometimes we have, sometimes not) (PM and QCM)
11. on all above-mentioned documents after revising based on the comments

12. for the project (PM)

## 2. Proposed Valtech Workflow Model

Figure 21 shows the proposed workflow of Valtech.

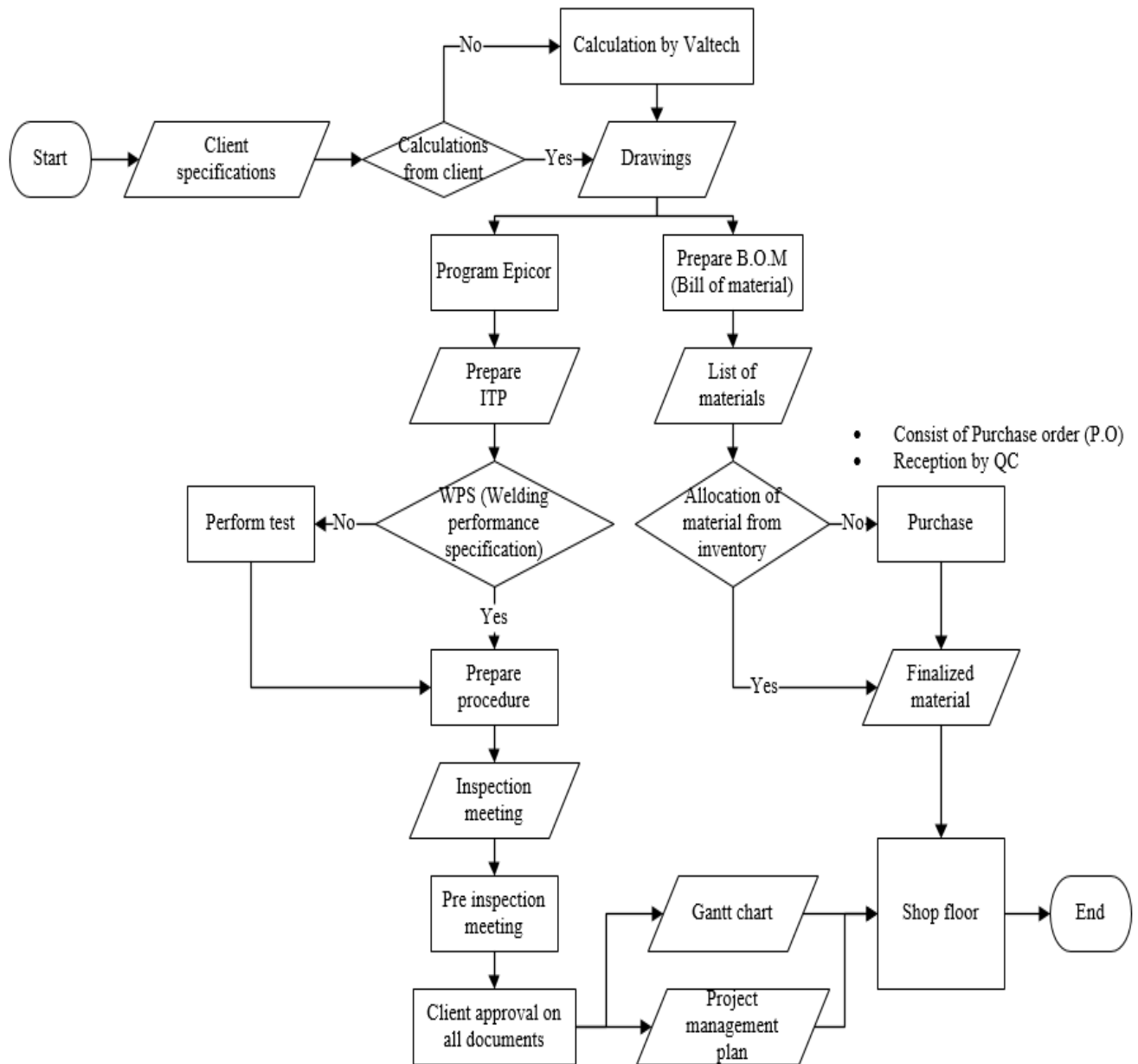


Figure 21- Proposed Valtech Workflow

### 3. Proposed Valtech Shop Floor Workflow Model

The Valtech Shop Floor Workflow Model was designed based on the draft workflow chart and proposed scenery of Valtech shop floor operation provided by Valtech based on their steps of fabrication operations. Figure 22 shows the shop floor workflow of Valtech.

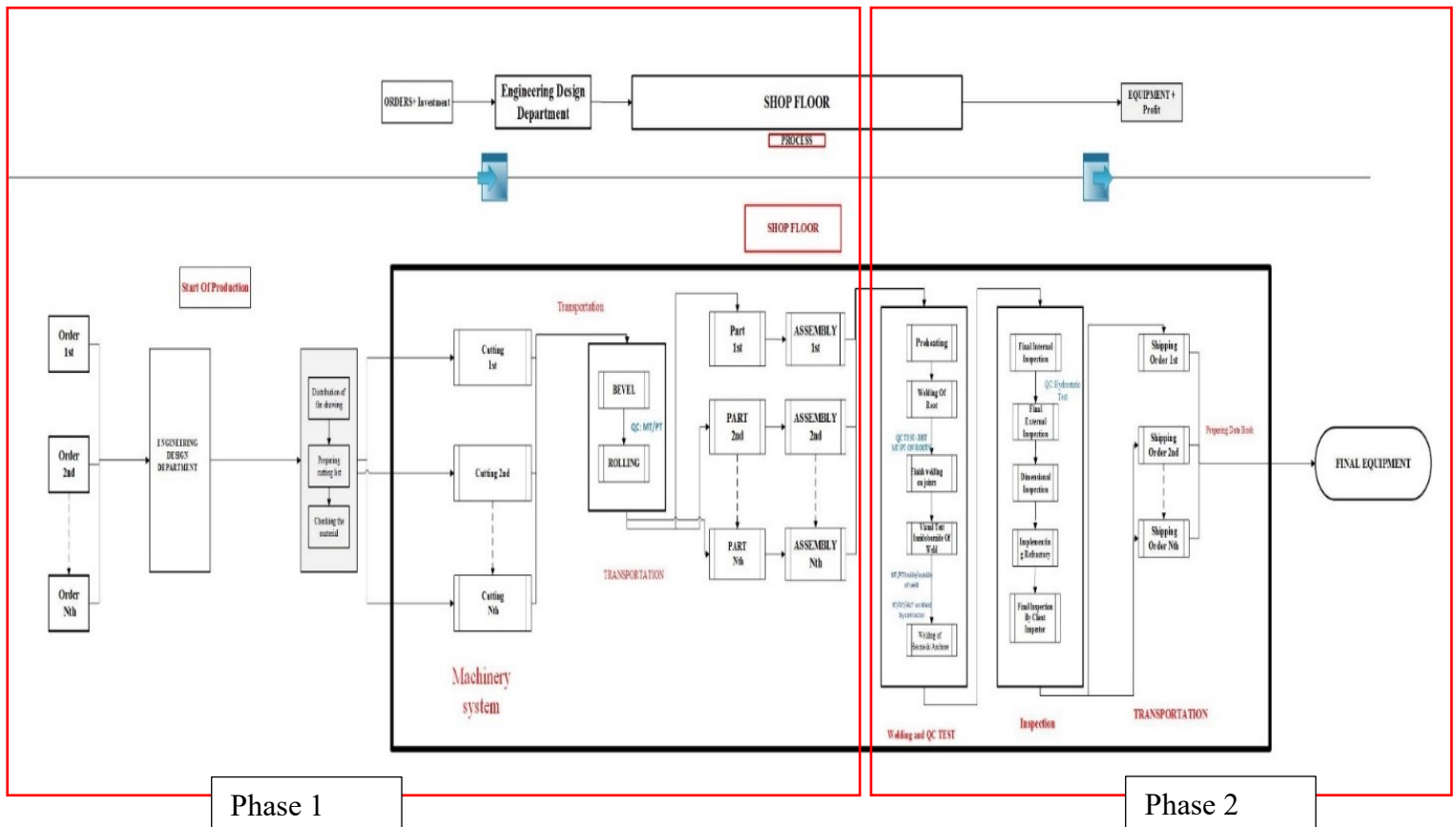


Figure 22- Proposed Shop Floor Workflow Model

Phase 1:

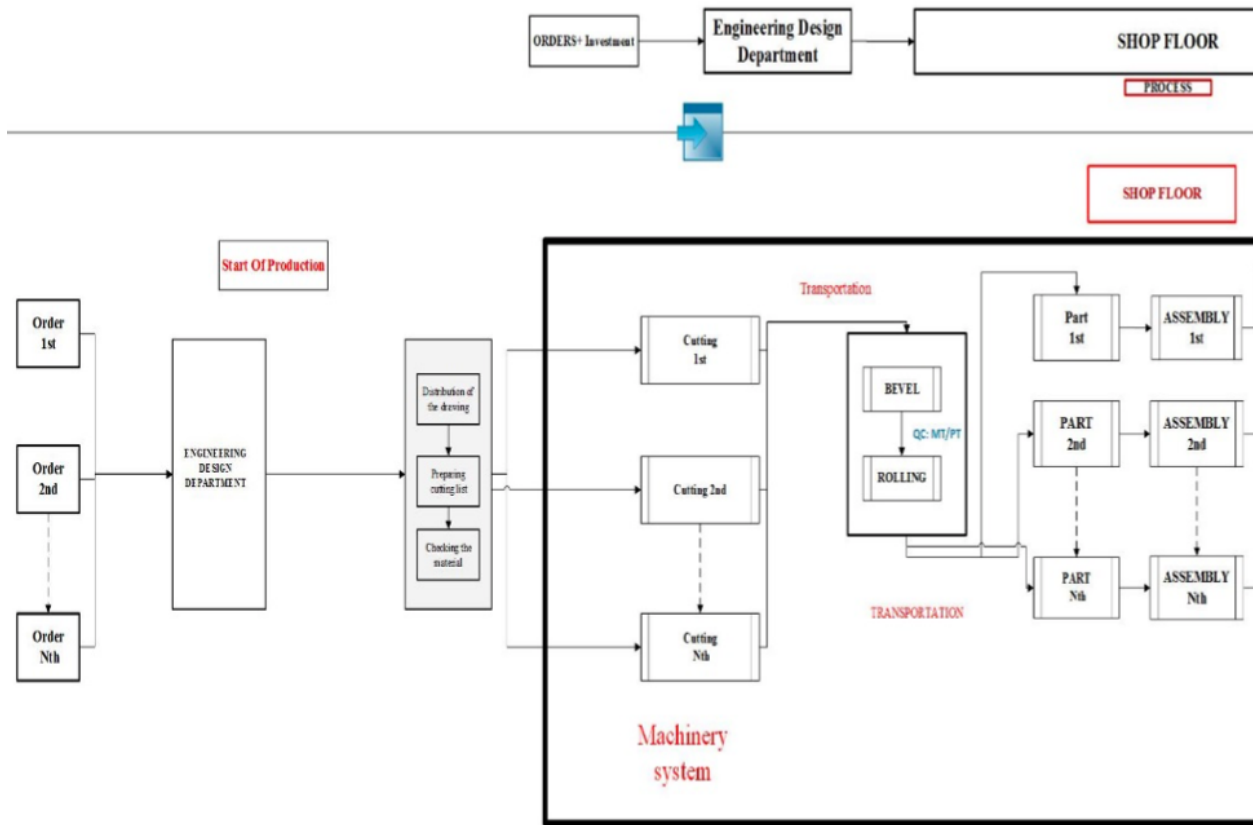




Diagram illustrating the flow of equipment and profit. A box on the left is connected by an arrow to a box labeled "EQUIPMENT + Profit". Below this, a blue arrow points to the right.



46

since most of their production operation is controlled using ERP system. For each project, Valtech adds all the production operations in their ERP system and all the workers have access to this system and has to punch their activities in ERP system. Managers of Valtech use ERP system to control their production and finance, but due to bad use of this system, it is not reliable. Having this system is costly for Valtech, and the production is dependent to this system, so finding a solution for this system was vital for Valtech. Figure 23 shows the information flowchart designed for information system of Valtech.

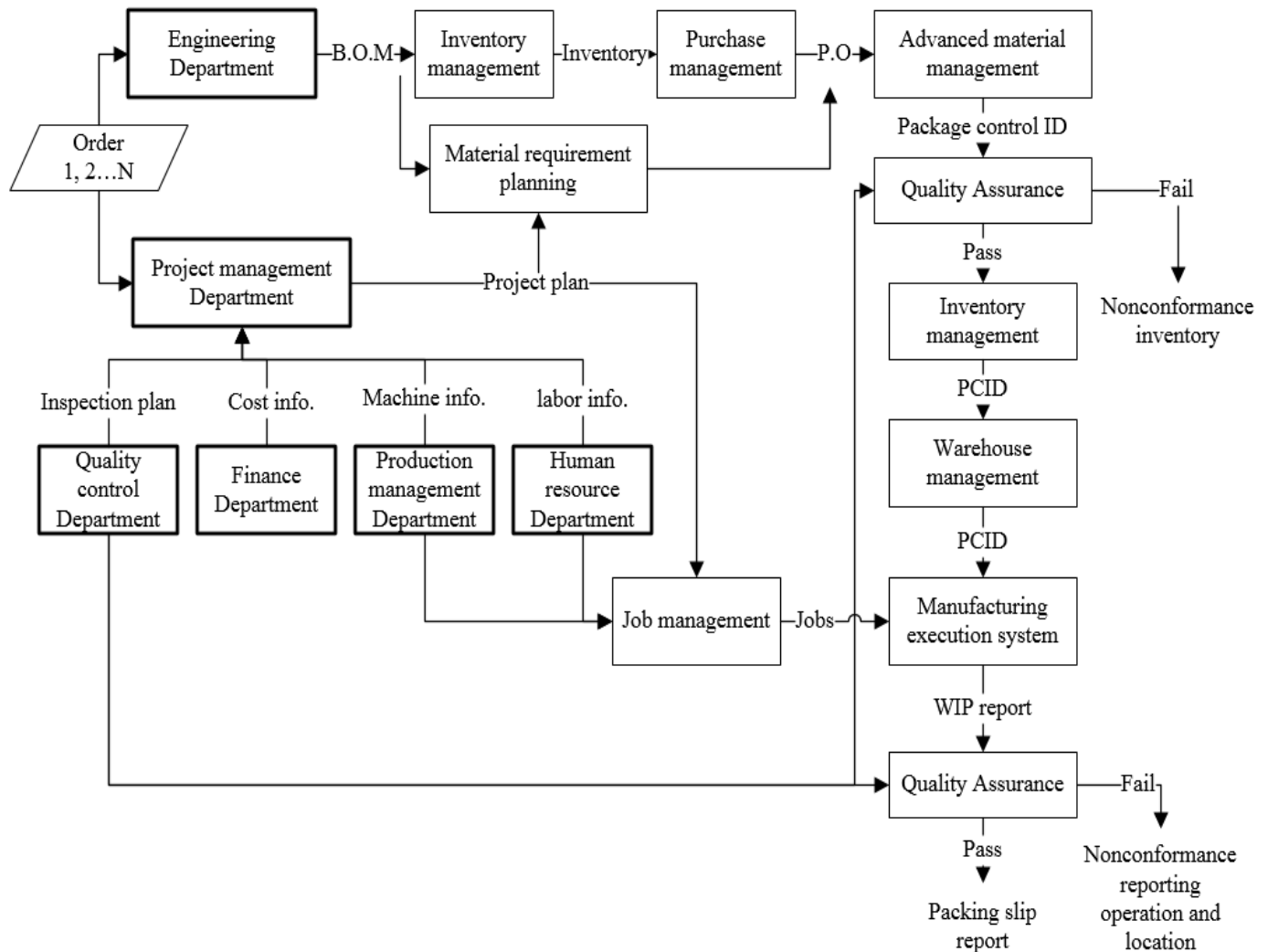


Figure 23- Information Flowchart

In order to identify the Valtech critical issues based on the proposed workflow model, a project discussion for Valtech examples conducted. Firstly, Valtech team provided the feedback of the draft model. Based on the model, Valtech team was asked to offer some typical examples of the problems during the Valtech manufacturing process. Then, the examples were analyzed using the ROM model.

## **5. Examples**

In order to verify the workflow model (Figure 21), research team applied it in analyzing certain examples from the real operation provided by Valtech. For the detailed description of the examples please refer to Appendix. Research team selected Case 1 (detail in section 3 of appendix) for further investigation.

### **Case 1**

"we have a big problem in material department that we don't have a fixed place for reception and always people spend lots of time finding the received material at the time they need them and in warehouse we have no tracking system or responsible to control the material. We wanted to solve this problem".

The analysis was started from drawing ROM diagram on the statement of the example. Based on the ROM diagram, a series of questions were asked and answered. Then the critical issue was identified. Finally, research team proposed the information flow model, the inventory and the warehouse management model which were stemmed from the proposed model as the solutions of the example.

### 5.1. Environment Analysis

Description: “we have a big problem in material department that we don’t have a fixed place for reception and always people spend lots of time finding the received material at the time they need them and in warehouse we have no tracking system or responsible to control the material. We wanted to solve this problem”

Figure 24 shows the ROM diagram of Valtech case 1.

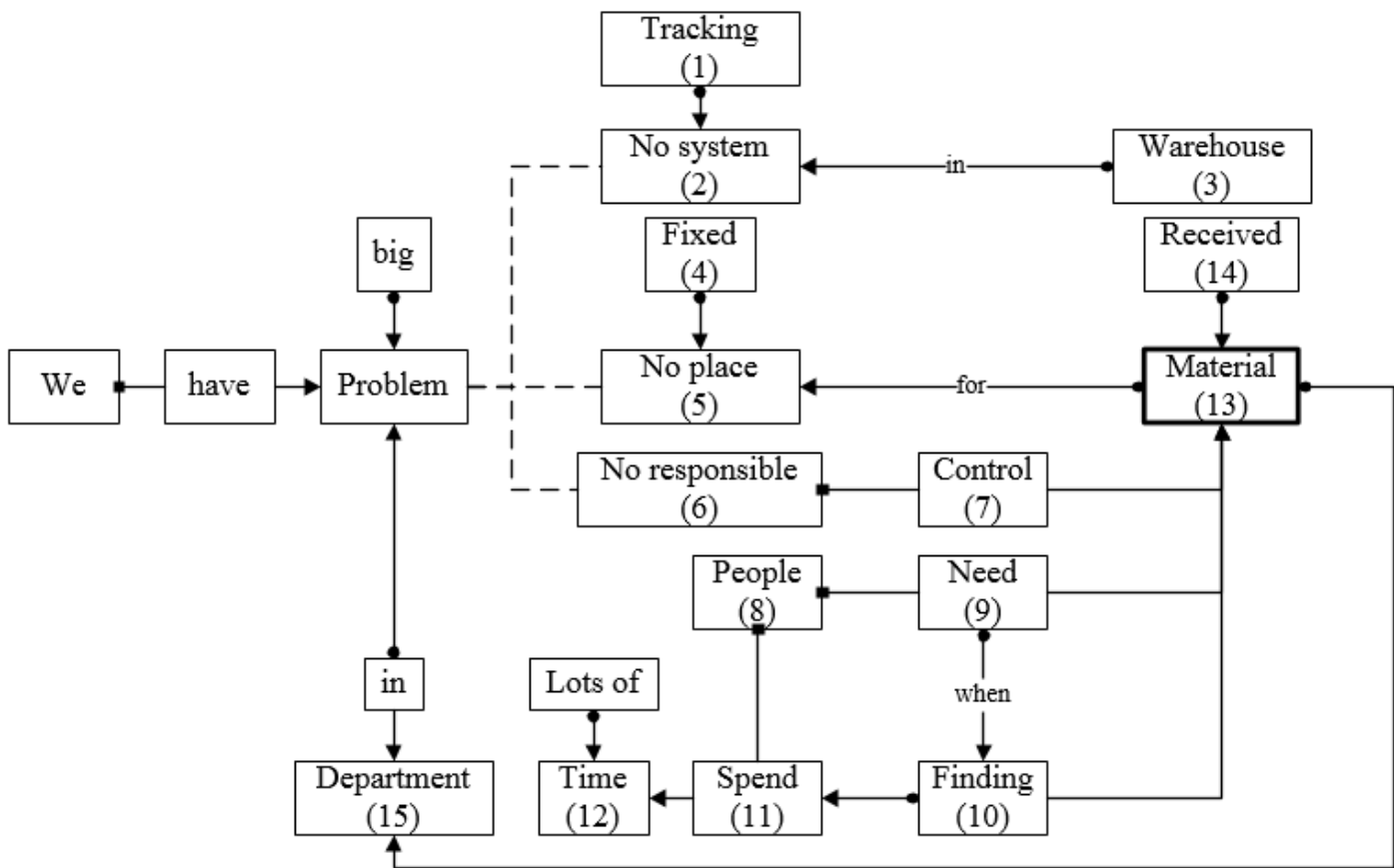


Figure 24- ROM Diagram of Valtech Case 1

## 5.2. Question list

### 1. What is tracking system?

A tracking system is used for the observing of persons or objects on the move and supplying a timely ordered sequence of location data for further processing. There are lots of tracking systems, normally, indoor assets are tracked repetitively reading by using passive and active automatic identification (RFID) and feeding read data into work in process models (WIP) or warehouse management systems (WMS) or ERP software.

### 2. What is 'fixed place'?

In the warehouse

### 3. Who is 'responsible'?

People in warehouse management department

### 4. How does 'responsible control the received material'?

Through warehouse management system

### 5. Who is 'people'?

Based on WIP models, people who need and find the received material should be identified.

### 6. How does 'people find the received material'?

This is the critical issue in warehouse management. On one hand, people can use RFID such as barcode or chips to label these materials, on the other hand, a well-organized warehouse management system is needed to solve this problem.

$r_{ij}$  as explained in chapter 3 refers to the relationship between object  $i$  and  $j$ .

$r_{ij} = 1$ : Objective  $i$  and  $j$  have a subject-verb relation

$r_{ij} = 2$ : Objective  $i$  and  $j$  have a verb-object relation

$r_{ij} = 3$ : Objective i and j have a constraint relation

Table 7- Relations for the Coded ROM Diagram

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1		3													
2															
3		3													
4					3										
5															
6							1								
7													2		
8									1		1				
9										3			2		
10											3		2		
11												2			
12															
13					3										3
14													3		
15															

Table 8- Number of Constraint and Predicate Relations on an Object

Number of relations	4	2	1
Object	13	2, 5, 11	7, 9, 10, 12, 15

According to the ROM diagram of Valtech case 1, based on the rules of ROM analysis [20], The central object in this ROM diagram is ‘Material’, which has the greatest number of constraint and predicate relations with other objects. Other objects with relative more undefined constraints are “system”, “place”. These objects should be considered with priority. But before clarifying these central words, the constraints of them should be refined first.

In environment analysis step, product environment can be decomposed into three categories, natural, built and human environment [23]. Natural environment includes time, cost and the fixed place (warehouse), human environment includes workers and the responsible in warehouse management department. In terms of the time dimension, built environment can be defined as product life cycle, and it can be demonstrated by a sequence of activities from workflow and information flow. In this case, the critical conflict is the material related work in the process model of Valtech and its warehouse management system.

### **5.3. Solution Generation**

Identified critical conflict pointed out the direction of the solution. The initial solution includes the modeling of purchase and inventory and warehouse management which are closely related with material work in process. These models are established on the basis of the general process model of Valtech.

## 6. Purchase Model

The flowchart of the draft purchase model is as follows. The dot line modules in the flowchart represent the proposed information systems in the flow. Figure 25 shows the Purchase Model designed for Valtech.

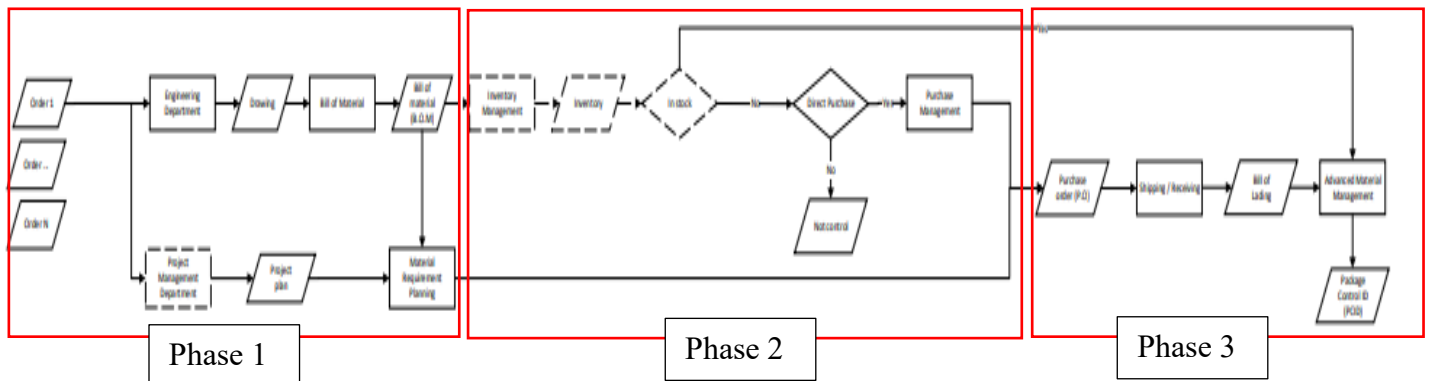
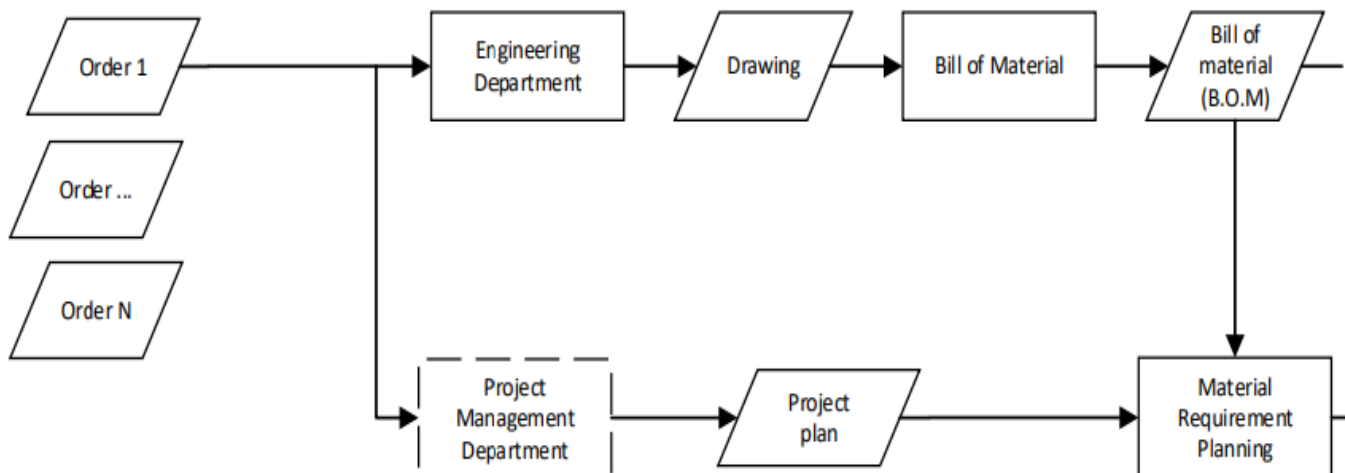


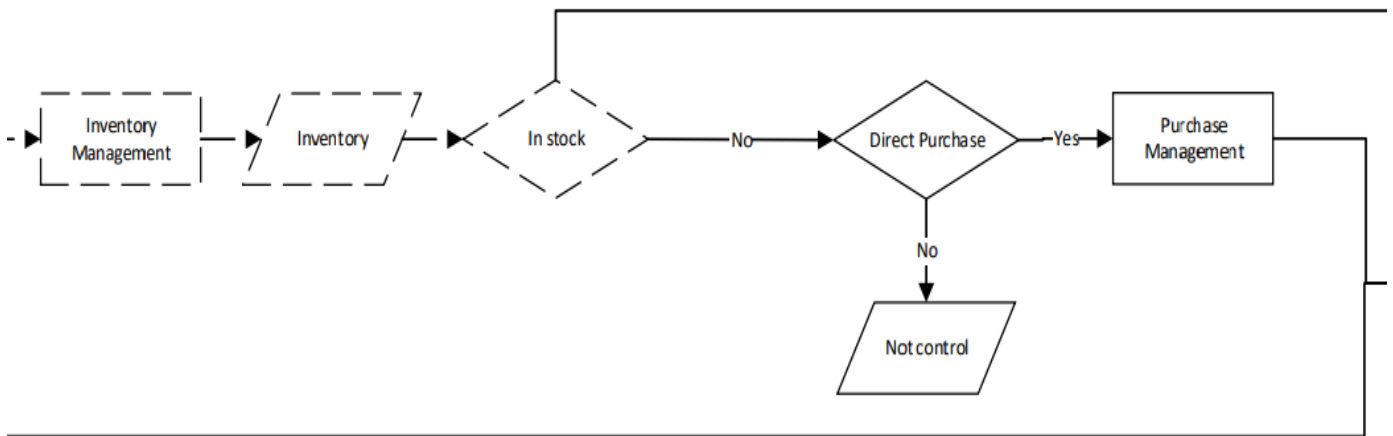
Figure 25- Purchase Model

Phase 1:

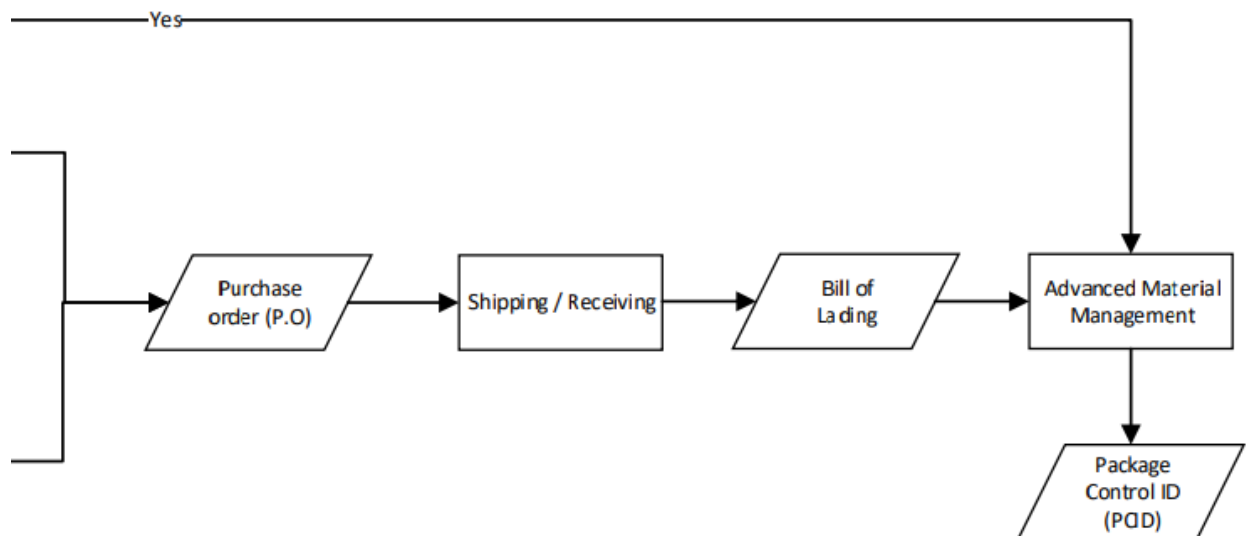




## Phase 2:



## Phase 3:



## 7. Inventory Model

Figure 26 shows the draft inventory model of Valtech.

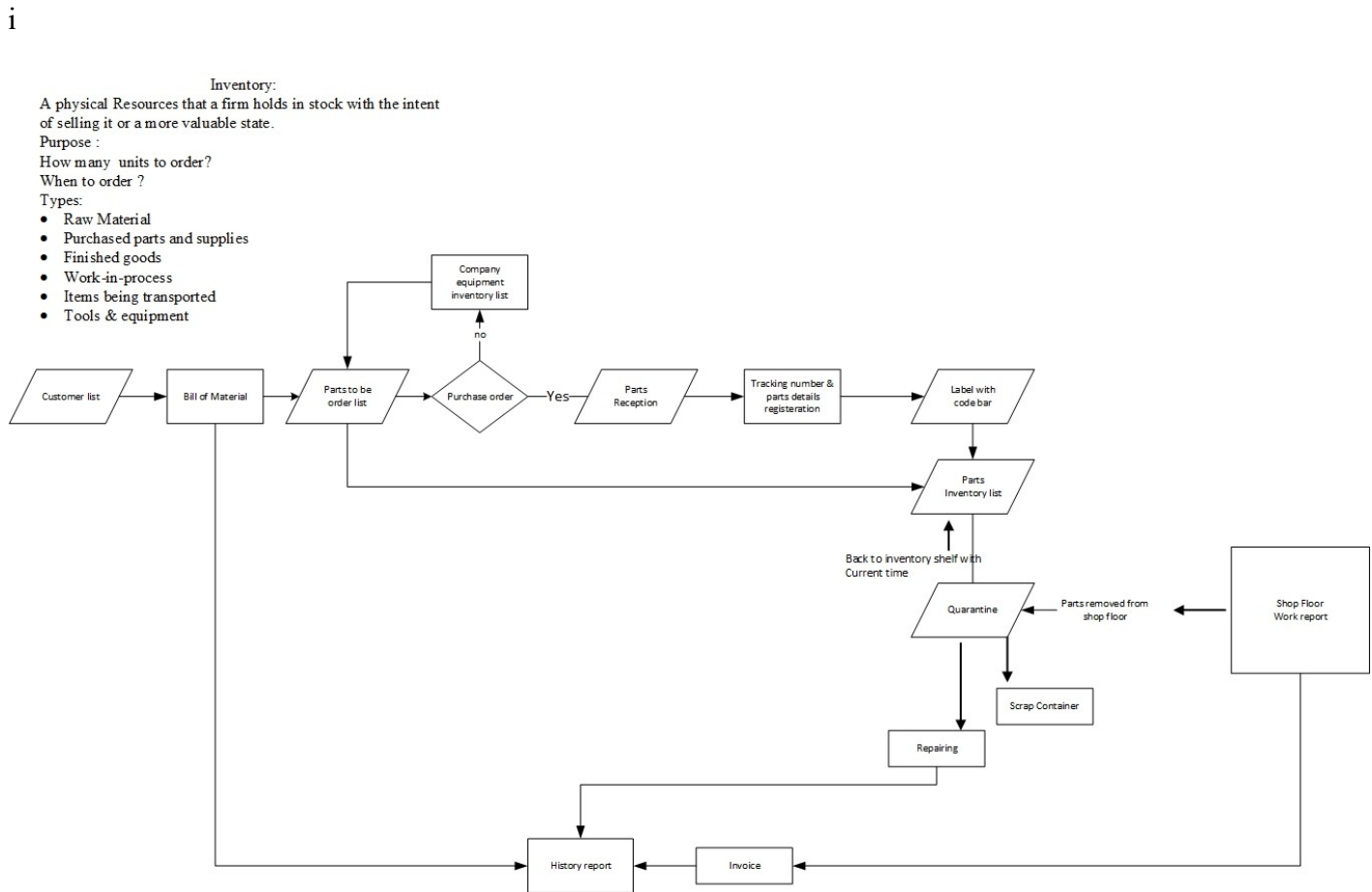


Figure 26- Inventory Model

Phase 1:

#### Inventory:

A physical Resources that a firm holds in stock with the intent of selling it or a more valuable state.

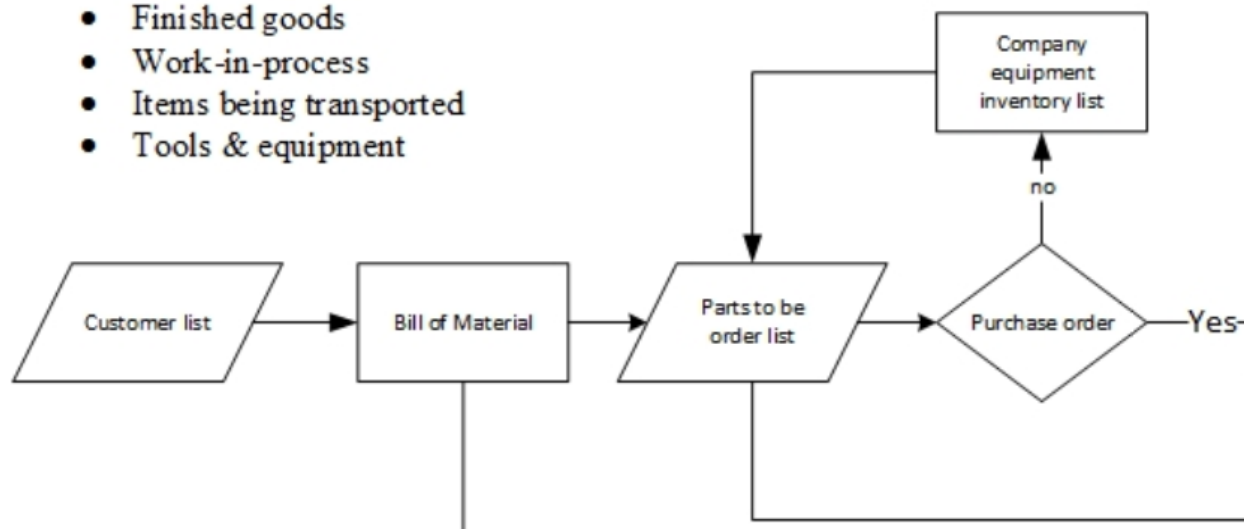
Purpose :

How many units to order?

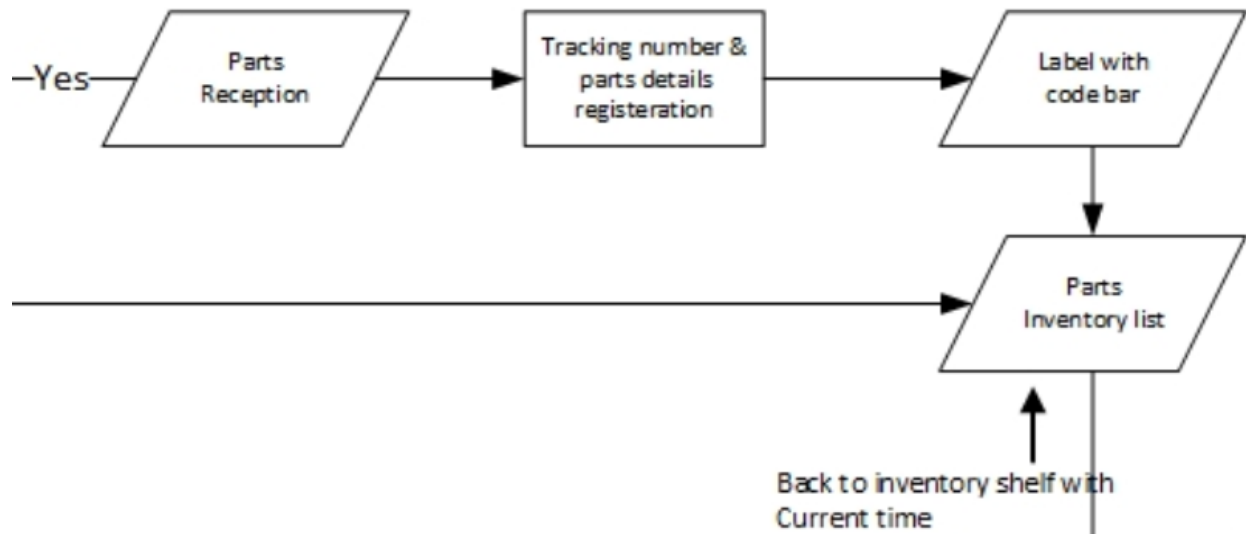
When to order ?

Types:

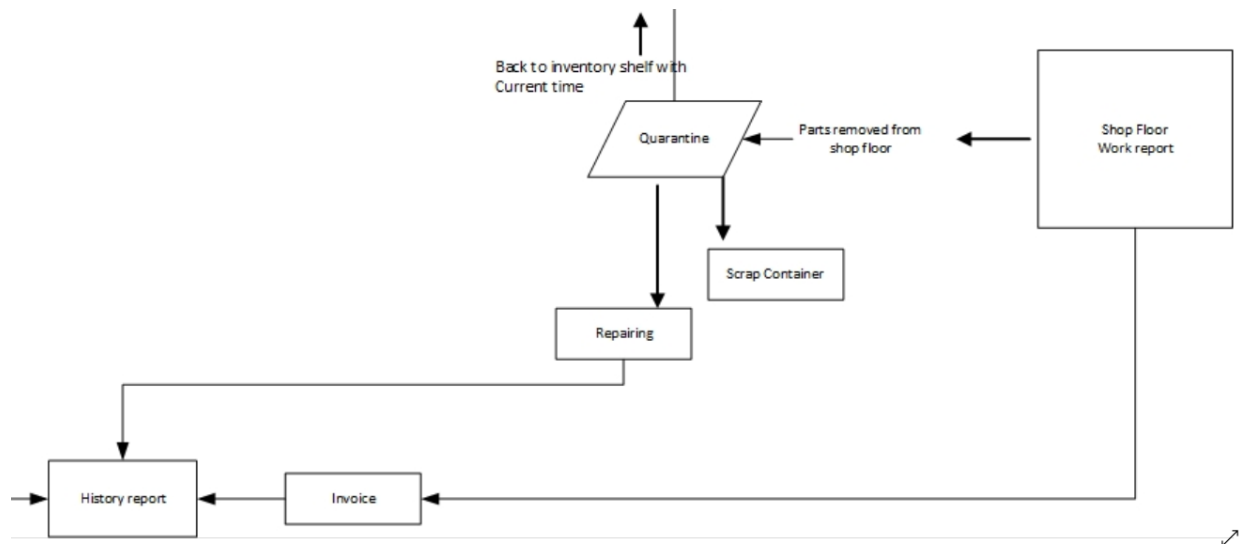
- Raw Material
- Purchased parts and supplies
- Finished goods
- Work-in-process
- Items being transported
- Tools & equipment



Phase 2:



Phase 3:



## 8. Warehouse Model

Figure 27 shows the draft warehouse model of Valtech.

Phase 1:

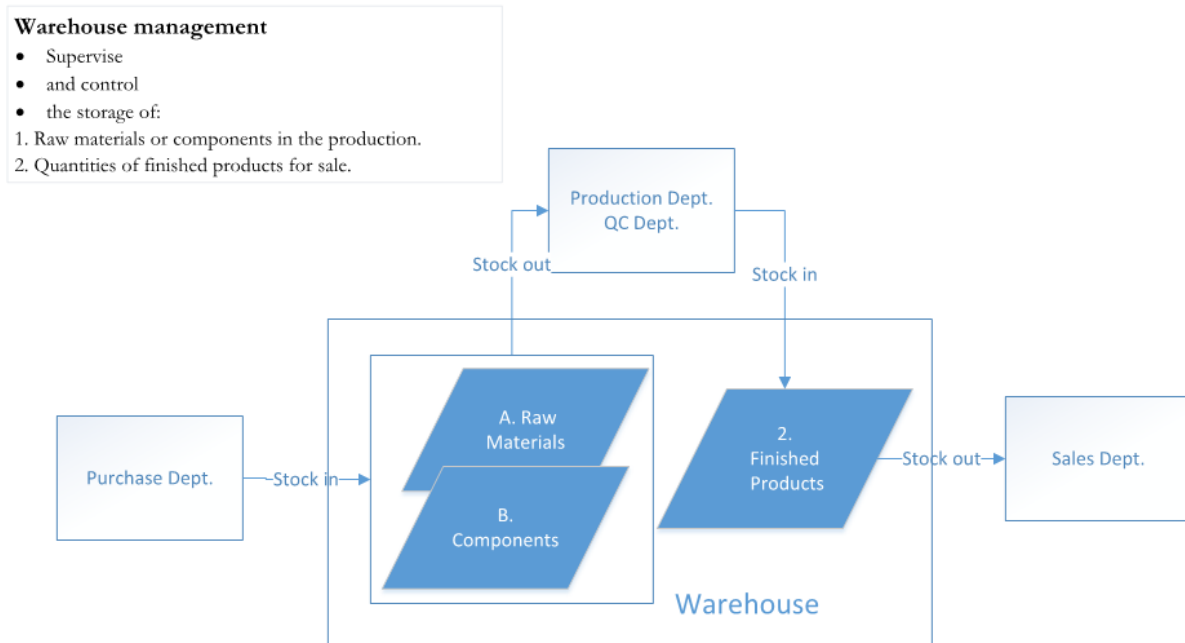
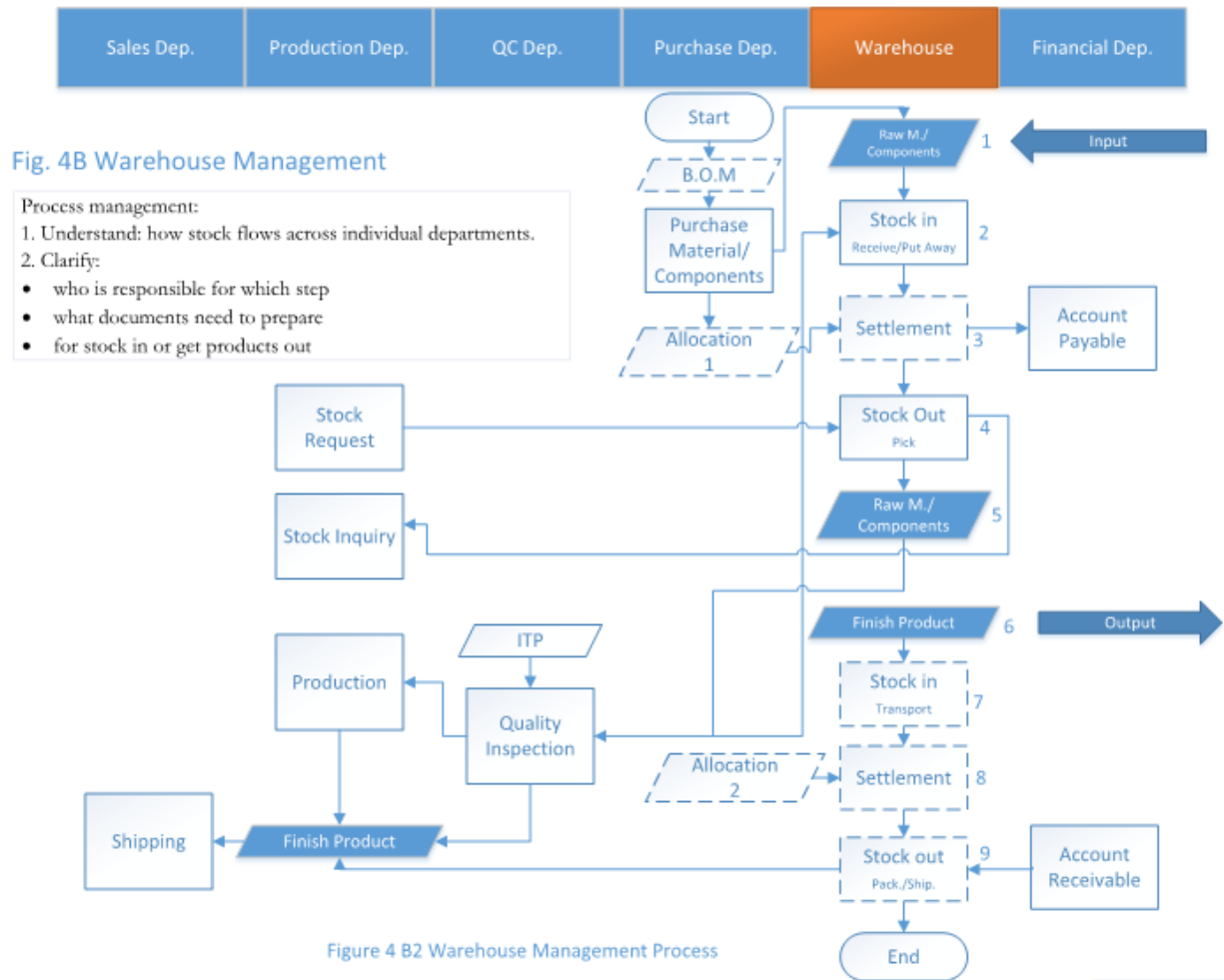


Figure 27- Warehouse Model

## Phase 2:



## 9. Proposed Solutions

Following our discussion and investigation and based on the analysis of the material workflow model using EBD method, the proposed solution guideline is as follows

- As the business is growing fast in Valtech, current capacity of the warehouse could hardly fulfill the need of inventory. A physical warehouse is suggested to build up or expand to catch up with the progress of Valtech development.
- Refine the work in process of material handling in Valtech. Based on this process, design a warehouse management system. Assign responsible people in charge of each action. The responsible ones might include the team of designer, project manager, purchaser, and construction team to manage the fast growth of Valtech in the future.
- To reduce the workload of the responsible people in warehouse management system, a system with RFID chips or barcode can make recording information automatically.
- Launch the change management, enabling the employees in Valtech to engage in the new system and new management.

# Chapter 5

## Conclusions and Future Work

### 1. Conclusion

The outcome of this project is a model-based approach using EBD to perform a deep environment analysis and find the main causes of issues and developing an efficient workflow for the company's operation. By setting up the model of the workflow, the industrial partner could have an overview of its working process. It helps the industrial to identify critical issues in practice, to find a root cause and look for solutions to improve the performance of the company's operations. The focus of this project was on Material Control of Valtech, and the solution provided only for this sector.

In Valtech case, the environment analysis shows the wrong implementation of ERP system not only did not help Valtech to solve the issue, but also became a new issue. Valtech has to invest on their resources to have a responsible for ERP system to manage the system and fill the shortages. On the other hand, as for material control sector of Valtech, a warehouse and a responsible for the warehouse was essential.

Valtech designed and constructed a warehouse following creating a new job as a Material Manager to take care of all material management from reception to storage and use. Valtech hired an information technician to take care of their ERP system.

Since there was no data before and after the changes, I was not able to perform quantitative analysis to see the improvement; however, all the managers and owners confirmed that the changes made the process more efficient and Valtech could save time and money in managing their material. The ERP system needs more time to show the results of improvement.



## **2. Future Work**

### **2.1. Complete and Optimized Workflow for Valtech**

Excellent performance of a company relies on the integrated and optimized workflow. This pilot project shows that there are a lot of works to do for Valtech. To achieve an effective and efficient workflow, we need to work on the following 3 steps in the future.

Step 1. Expand the analysis and models into the sub workflows for various departments, thus integrating an overall and complete workflow for Valtech.

Step 2. Analyze the conflicts in the workflow. Optimize the complete workflow by solving these conflicts with EBD.

Step 3. Identify the information flow and necessary resources from the optimized workflow by using Environment Analysis of EBD. This step helps to enable smooth integration with ERP system.

### **2.2. Change Management**

The introduction of ERP system and the new workflow will bring changes to the operation in Valtech. However, change causes resistant from employees. Change resistance is the major reason for the failure of changes in organizations. For better implementation of ERP and new workflow, it is important to manage change in a scientific way.

Stress-Performance model was developed for performance improvement. In Valtech, we need to apply this model in change management. Based on the optimized workflow, we have to perform management change following the steps:

- Analyze the current status of employees from EBD perspective;
- Find out the root causes of change resistance with Stress-Performance model;
- Suggest the action list for a better change result.

### **2.3. Tools for Decision-Making in Change Management – Change Management Simulator**

In the ever-changing world, companies have to take change as part of their operation. Organizational change involves aspects such as culture, regulations, process, resources, the status of employees, etc., making the managers heavily stressed in making decisions for change management.

In order to reduce the workload of managers in change management, we will work on a tool for managers in decision making in form of a change management simulator. The simulator is the application of EBD and Stress- Performance model in change management. Its function includes:

- ✓ Analyze the purpose of the change;
- ✓ Derive the workload due to the change;
- ✓ Identify the status of employees,
- ✓ Find out the factors and their priorities of change management;
- ✓ Provide the necessary actions.

With this simulator, managers are able to obtain the suggestions on decisions in change management as long as inputting the necessary information for change management.

### **2.4. Limitation: Quantitative Analysis**

To be able to perform quantitative analysis we need to have data before and after implementation of changes. In this research I was not able to perform the quantitative analysis since Valtech does

not have data before and after the changes; however, Valtech is able to activate the data collection section of their ERP system to make this possible in future research.

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# Appendix

## 1. Valtech Working Steps

### 1) Working steps after signing a contract

1. Reading the client specification (different for any client) (PM and QCM)
2. Preparing the calculation (sometimes we prepare, sometimes comes from client, for expansion joints comes from Valtech Engineering)
3. Preparing the drawings (sometimes we prepare, sometimes comes from client, for expansion joints comes from Valtech Engineering)
4. Preparing B.O.M (bill of materials) based on the drawings
5. Allocating material to the project (if we have in inventory we use it, if not we buy; however, even if we have in inventory, but we find cheap material in the market (due to any reason) we buy) purchase of material is consist of creating purchase order (P.O) and do the reception by QC (in need I can give information in detail) and etc.(PM)
6. Programming Epicor for that project based on weld joints (picture 1) (PM)
7. Preparing WPS (welding performance specification) if do not have already. (QCM)
8. Preparing procedures for each test such as heat treatment, hydro test, Visual test, etc. (QCM)
9. Preparing ITP (inspection and test plan) (QCM)
10. Holding PIM (pre-inspection meeting) with client for clarifying their needs (kick off meeting) (sometimes we have, sometimes not) (PM and QCM)

11. Get client approval on all above-mentioned documents after revising based on the comments.

12. Preparing Gantt chart and planning for the project (PM)

2) Start of the production

1. Distribution of the **drawings** to foreman, and QC

2. Preparing the **cutting list** (I will check the material before cutting to make sure they meet the requirements of the client)

3) Production and Quality Control following steps:

1. Cut

2. Bevel

3. MT/PT after bevel: MT (Magnetic particle test / PT (liquid penetration test)

4. (QC) (depends on the requirements of the client)

5. Rolling

6. Assembly of the part or joint

7. Preheating (depends on the material. Sometimes we have, sometimes not)

8. Welding of the root

9. DHT (de-hydrogenizes)

10. MT/PT on the root (QC) (depends on the client's requirement)

11. Finish welding on the joint

12. Visual test inside and outside of the weld (QC)

13. MT/PT inside and outside the weld (depends on the client's requirement)



14. RT/UT/PAUT on the welds by sub-contractor (QC prepares the request form indicating all the information about that joint and ask them to come and perform the test. Then QC is responsible to get the report, verify them and if all are accepted keep in data book, if not ask for repair). For more information, let me know to provide you.
15. It can be full, spot or none (depends on the project and the part).
16. Welding of hex mesh or anchors for refractory.
17. Heat treatment (depends on the material. Sometimes we have, sometimes not.  
  
Sometimes for some parts of the project we have, not all parts). Note: after heat treatment, if we make a weld repair, or add more weld, we need to redo the heat treatment, so it is very important to make sure the inspections before heat treatment are done to reduce the risk of rework.
18. Visual inspection. PT/MT after heat treatment.
19. RT/UT/PAUT on the welds after heat treatment. It can be full, spot or none.
20. Final internal inspection (QCM and AI)
21. If there is no repair, we can go for hydro static test. (QCM and AI as well as client inspector) note: sometimes we have hydro test, sometimes not. Some of the project are with AI, some not.
22. Final external inspection (QCM and AI)
23. Dimensional inspection
24. Implementing refractory. Note: sometimes we perform refractory on some parts in former steps.
25. Refractory inspection consists of visual and hammer test.
26. Final inspection by client inspector

27. Inspection release by client inspector (some projects we need, some not)
28. Preparing for shipping
29. Shipping
30. Preparing the data books with all documents used in fabrication (usually more than 500 pages)

4) Workflow of a plate

1. Preparing the P.O
2. Purchase of material
3. Receiving the material and storing in reception zone
4. Giving the packing list to QC responsible person
5. Verifying the packing list with the P.O
6. Verifying with client specification
7. Verifying the MTR with code and approving it by stamp
8. Doing inspection on the received material
9. Doing receipt entry in Epicor and approving the P.O to be paid.
10. Stick a tag on the plate
11. Storing the material in the store zone
12. Give the new location to IT to enter in Epicor
13. The first cut of the plate, a sample will be given to QC for PMI (positive material identification)
14. The remaining of the plate with new size and location will be entered in Epicor adding a number in front like 1 or 2 if the remaining is only one piece or more
15. QC will add PMI report to MTR.

## 2. Feedback of the Valtech Model

### 1) Feedback from the QC manager

#### I. Valtech Workflow (Initiation and Planning phase)

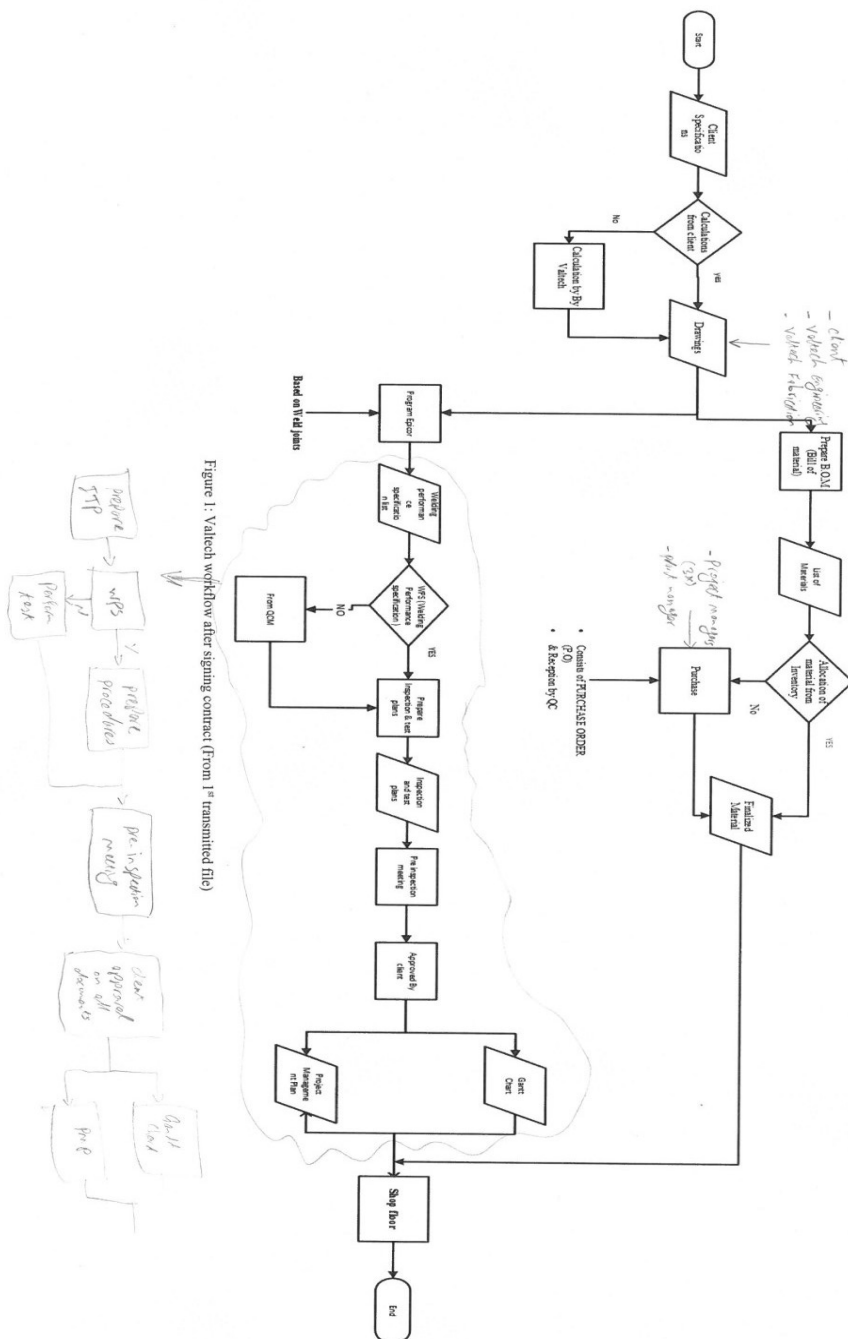
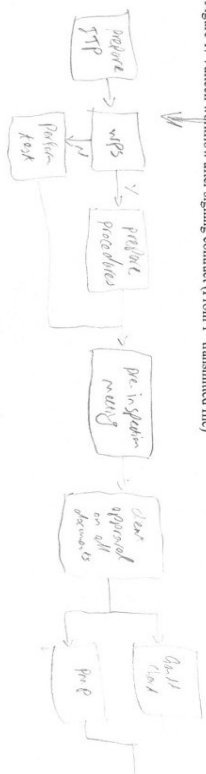


Figure 1: Valtech workflow after signing contract (from 1<sup>st</sup> transmitted file)



## II. Workflow Model (Cumulative phase)

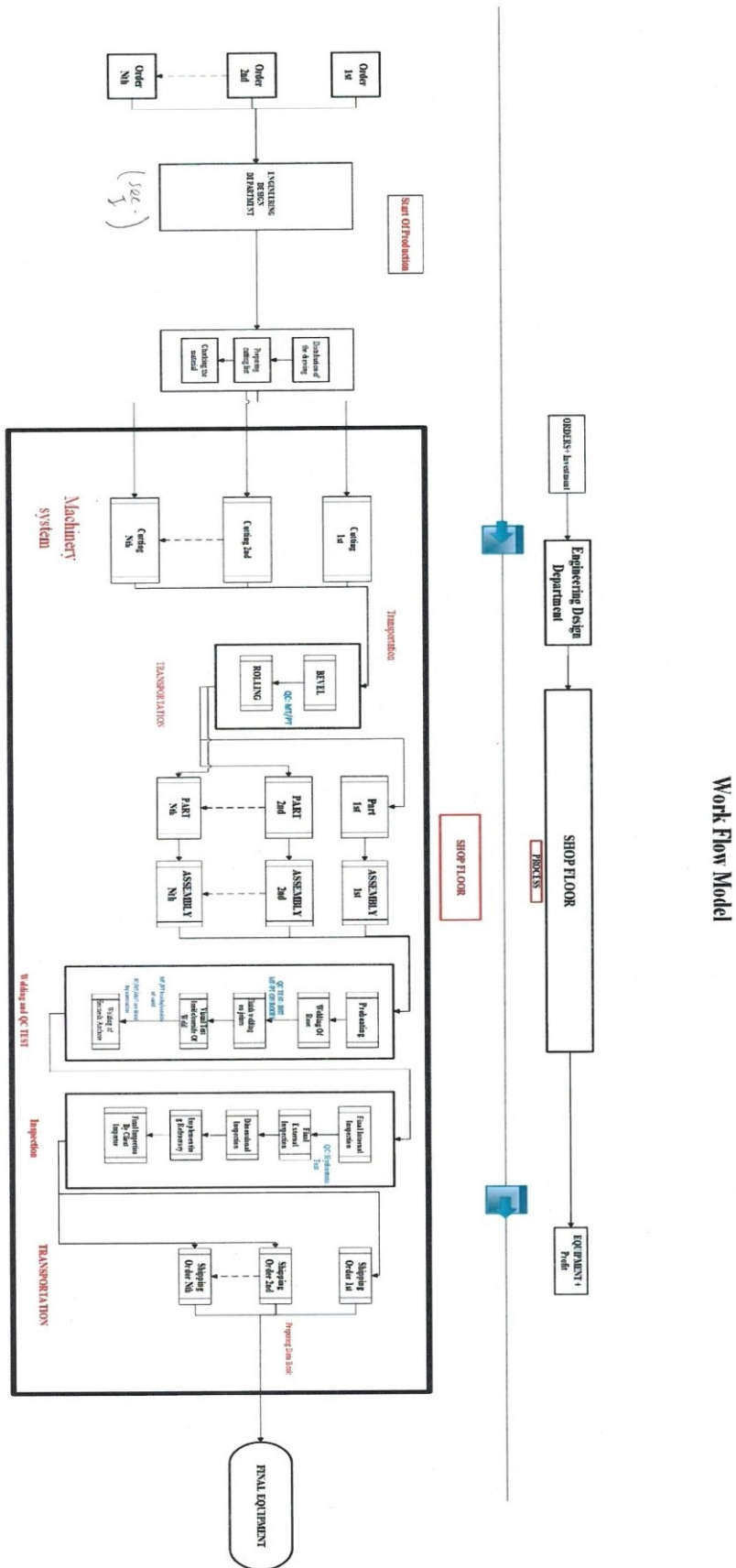


Figure 2: Workflow Model





### 1) Case 1

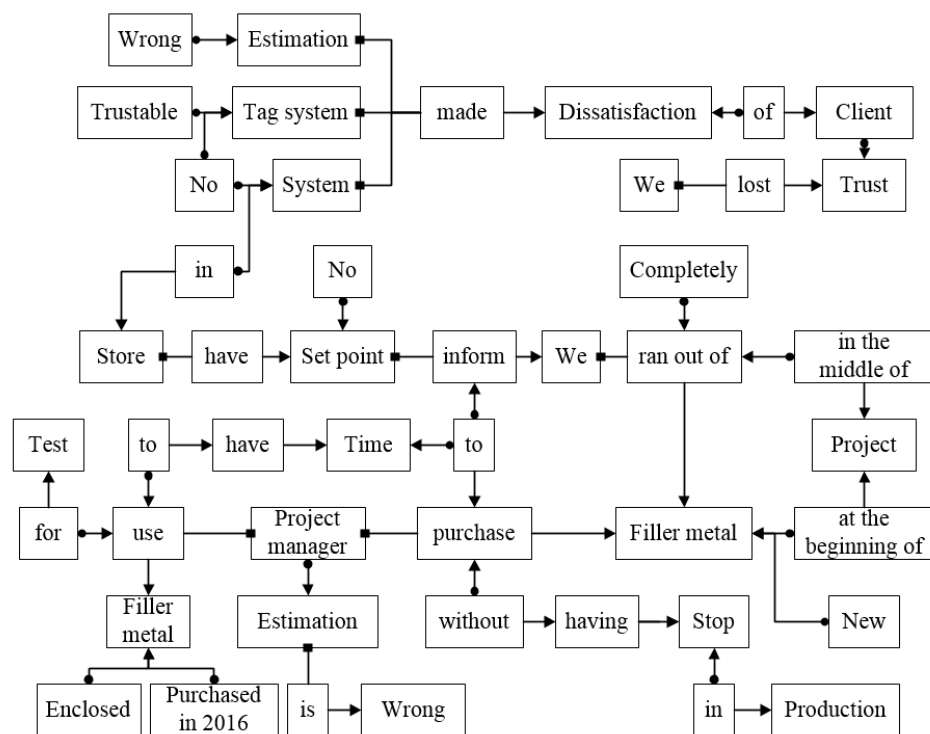
```

graph TD
    We[We] --> have[have] --> Problem[Problem]
    Problem --> big[big]
    Problem --> in1[in] --> Department[Department]
    Problem --> Tracking[Tracking]
    Problem --> NoSystem[No system]
    Problem --> NoPlace[No place]
    Problem --> NoResponsible[No responsible]
    Problem --> Control[Control]
    Problem --> People[People]
    Problem --> need[need]
    Problem --> when[when]
    Problem --> Finding[Finding]
    Problem --> spend[spend]
    Problem --> Time[Time]
    Problem --> Warehouse[Warehouse]
    Problem --> Received[Received]
    Problem --> Material[Material]
    Tracking --> NoSystem
    NoSystem --> in2[in] --> Warehouse
    fixed[fixed] --> NoPlace
    NoPlace --> for[for] --> Material
    NoResponsible --> Control
    Control --> for --> Material
    People --> need
    need --> when --> Finding
    Finding --> spend
    spend --> Time
    Time --> in1 --> Department
    Warehouse --> Received
    Received --> Material
    Material --> in1 --> Department
  
```

## 2) Case 2

- The project manager purchased filler metal at the beginning of the project, but in the middle of the project we ran out of filler metal. The store has no set point to for example when we

get to 20% of inventory, inform us to purchase more. They informed us when we ran completely out of material.



ROM diagram of Valtech case 2

- The project manager used the enclosed filler metal, which was purchased in 2016 for test, to have time to purchase new filler metal without having stop in production. In QC we found it as a wrong filler metal with a wrong tag, so the project went on hold until the new material arrives.
- NCR



Valtech Fabrication Inc.

RAPPORT DE NON-CONFORMITE  
NON-CONFORMANCE REPORT

Form. 1-1-1

NCR-2018int-01 rev 0

4100-03-01

No.d'item/Item No.: C03

No.commande Mat./Matl purchase order: 451879#663

Date/Date: June 12, 2018

Client/Client: Motive Norris

Dessin/Drawing:

Fournisseur/Supplier:

Description de la non-conformité/Description of non-conformity:

The filler metal with the tag number WD000604 which was used for welding of C03 found unacceptable due to having different chemical analysis as EB3R.

Signature/Signature: \_\_\_\_\_ Date/Date: June 12, 2018 Titre/Title: Q.C. Manager

Disposition recommandée/Recommended disposition:

The filler metal was purchased in 2016 for test as EB3R, but seems the wrong tag was installed on some of them.  
The weld of joint C03 was removed and the PMI confirmed the removal was complete.  
The tag was removed from the filler metal because it was EB2.  
All the joints welded with this tag number were tested to make sure they were correct.  
All the filler metals with the same tag were tested in store to find the wrong ones.

Procédure /Procedure

Signature/Signature: \_\_\_\_\_ Date/Date: June 12, 2018 Titre/Title: Q.C. Manager

Approbation de la disposition /disposition approval

Ingénieur en chef/Chief engineer \_\_\_\_\_ Directeur A.Q./Q.I. Manager \_\_\_\_\_  
I.A./A.I. \_\_\_\_\_

Vérification de la disposition/Disposition verified:

Inspecté par/Inspected by: \_\_\_\_\_ Date/Date: \_\_\_\_\_ Titre/Title: \_\_\_\_\_

Revue par inspecteur autorisé/Authorized inspector review:

Accepté/Accepted: ☐

Rejeté/Rejected: ☐

C.C.

Ingénieur en chef/Chief engineer: ☐

Client/Client: ☐

Directeur A.Q./Q.I. Manager: ☐

Directeur opération/Operation manager: ☐

I.A./A.I.: ☐

Autre/Other: ☐

Action corrective no./Corrective action No. \_\_\_\_\_

### 3) Scenario 1

Before refractory installation

- QC (Quality control) for all the projects shall do VT, MT, and RT.
- CI (client inspector) for some of the projects shall do VT (for some of the projects we do not have client inspector).
- AI (Authorized Inspector) shall perform VT only on the projects registered in Canada.

operation	Responsible to do or make sure it is done	Department
VT	A and B	QC
MT	A and B	QC
RT	C	QC
VT	A	CI
VT	C	AI

- For this project, we had QC, CI, and AI.
- In Epicor, there is no operation for CI, or AI, so, by verifying Epicor no one can know if AI, and CI performed their inspection or not. There are 6 big shop that sometimes you cannot find the parts, as well you do not have time to check the parts one by one to make sure their tests are performed or not. Even writing on them is not a solution.
- A is responsible to release the parts for refractory installation. Before giving release, he checks in Epicor if all the inspections before refractory are performed, then release.
- C found later that refractory is done, but AI has not done his inspection, which resulted NCR (non-conformity report).

#### **4) Scenario 2**

- Warehouse is responsible to transfer filler metal from its original package to an oven that welder will pick up to use in the shop.
- On the oven, there is a tag with diameter of filler metal, project in which the filler metal will be used, and material.
- On original package of filler metal also a tag will be installed at the time of reception including diameter, project or inventory (sometimes filler metal is purchased specifically for a project, sometimes for inventory to use later on a project), and material.
- The new hired warehouse responsible transferred the filler metal to the oven by considering the diameter and the project.
- Welder picked up the oven and worked for a day before realizing the filler metal in the oven does not match with the tag of the oven, which resulted a NCR, and some days of rework to remove the weld and re-weld with the right one.

#### **5) Scenario 3**

- For a project we have drawing, and Epicor will be prepared based on the drawing by project manager. Later president and project manager due to lack of time and overload of the shop decided to fabricate most of the parts of the project in sub-contractor company, some from scratch, some after we performed some of the operations.
- President, project manager, and production manager who are owners are aware of the details of this decision, but not QC.
- Later we received the fabricated parts and by that time, we realized what was going on.

- So now, the Epicor is not update and no one knows which joints are fabricated in the shop which not. The joints welded with sub-contractor are still in Epicor. No one even project manager does not know what is going on this project, or which tests are performed, and which are remaining. What tests the sub-contractor performed what not.
- I spent couple of days to have list of the joints and required tests. Separate the joints welded in Sub-contractor Company from what in our shop, find out up to what operation was performed in our shop before sending them to sub-contractor, remove the performed tests, and finally have a list of what we have to test to solve part of a problem. The job finished with all approval, but documents and data book is a new challenge.